

GE Healthcare
Life Sciences

WAVE Bioreactor™ 20/50 and WAVEPOD™ II

Operating Instructions

Original instructions



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1 Introduction

Purpose of the *Operating Instructions*

The Operating Instructions provides you with the instructions needed to install and operate WAVE Bioreactor 20/50 and WAVEPOD II in a safe way.

Prerequisites

In order to operate the WAVE Bioreactor and WAVEPOD II instruments safely and in the way it is intended, the following prerequisites must be fulfilled:

- You should be acquainted with the use of general laboratory equipment and with handling of biological materials.
 - You must read and understand the Safety Instructions chapter in this manual.
 - The system should be installed according to this manual.
-

In this chapter

This chapter contains the following sections:

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1.2 Regulatory information	10
1.3 WAVE Bioreactor system	12
1.4 WAVE Bioreactor 20/50 user documentation	15
1.5 Associated documentation	16

1.1 Important user information

Read this before using WAVE Bioreactor 20/50



All users must read the entire *Operating Instructions* before installing, operating, or maintaining the instrument. Always keep the *Operating Instructions* at hand when operating WAVE Bioreactor 20/50.

Do not operate WAVE Bioreactor in any other way than described in the user documentation. If you do, you may be exposed to hazards that can lead to personal injury, and you may cause damage to the equipment.

Intended use

WAVE Bioreactor 20/50 is intended to be used as research, development and manufacturing equipment for expansion of cells.

Note: *When used for cell therapy applications outside the European Union and Australia, for research use only.*

Safety notices

This user documentation contains WARNINGS, CAUTIONS and NOTICES concerning the safe use of the product. See definitions below.

Warnings



WARNING

WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury. It is important not to proceed until all stated conditions are met and clearly understood.

Cautions



CAUTION

CAUTION indicates a hazardous situation which, if not avoided, could result in minor or moderate injury. It is important not to proceed until all stated conditions are met and clearly understood.

Notices



NOTICE

NOTICE indicates instructions that must be followed to avoid damage to the product or other equipment.

Notes and tips

Note: *A Note is used to indicate information that is important for trouble-free and optimal use of the product.*

Tip: *A tip contains useful information that can improve or optimize your procedures.*

Typographical conventions

Software items are identified in the text by ***bold italic*** text. A colon separates menu levels, thus ***File:Open*** refers to the ***Open*** command in the ***File*** menu. Hardware items are identified in the text by **bold** text (e.g., **Power** switch).

1.2 Regulatory information

This section lists the directives and standards that are fulfilled by WAVE Bioreactor 20/50 and WAVEPOD II.

Manufacturing information

The table below summarizes the required manufacturing information. For further information, see the EC Declaration of Conformity document.

Requirement	Content
Name and address of manufacturer	GE Healthcare Bio-Sciences AB, Björkgatan 30, SE 751 84 Uppsala, Sweden

CE Conformity

This product complies with the European directives listed in the table, by fulfilling the corresponding harmonized standards.

Directive	Title
2006/42/EC	Machinery Directive (MD)
2006/95/EC	Low Voltage Directive (LVD)
2004/108/EC	Electromagnetic Compatibility Directive (EMC)

International standards

This product fulfills the requirements of the following standards:

Standard	Description	Notes
EN 61010-1, IEC 61010-1	Safety requirements for electrical equipment for measurement, control, and laboratory use.	EN standard is harmonized with EU directive 2006/95/EC
EN 61326-1, IEC 61326-1 (Emission according to CISPR 11, Group 1, class A)	Electrical equipment for measurement, control and laboratory use - EMC requirements.	EN standard is harmonized with EU directive 2004/108/EC
EN ISO 12100	Safety of machinery. General principles for design. Risk assessment and risk reduction.	EN ISO standard is harmonized with EU directive 2006/42/EC

CE marking



The CE marking and the corresponding Declaration of Conformity is valid for the instrument when it is:

- used as a stand-alone unit, or
- connected to other CE marked instruments, or
- connected to other products recommended or described in the user documentation, and
- used in the same state as it was delivered from GE Healthcare, except for alterations described in the user documentation.

The Declaration of conformity is valid only for systems that are marked with the CE-marking.

Regulatory compliance of connected equipment

Any equipment connected to the WAVE Bioreactor system should meet the safety requirements of EN 61010-1/IEC 61010-1, or relevant harmonized standards. Within EU, connected equipment must be CE marked.

1.3 WAVE Bioreactor system

Introduction

The WAVE Bioreactor instrument family has been designed for cell culture, enabling scale-up from 0.1 L to 500 L of culture volume, using a disposable bioreactor chamber. The cell culture volume for WAVE Bioreactor 20/50 spans from 0.1 L to 25 L. Oxygen transfer and mixing are accomplished by the principle of wave-induced agitation.

A single use, gamma treated bag called Cellbag™ bioreactor is placed on the WAVE Bioreactor instrument. The Cellbag bioreactor is inflated with gas, partially filled with culture medium, and is then inoculated with cells.

This section gives an overview of the family of WAVE Bioreactor systems. For detailed information about the WAVE Bioreactor 20/50 instrument, see *Chapter 3 System description, on page 35*.

Illustration of the system

The illustration below shows a WAVE Bioreactor 20/50 instrument.



The illustration below shows the optional WAVEPOD II controller, which can be connected to WAVE Bioreactor 20/50 and used to control culture parameters.



Tip: The software UNICORN™ DAQ 1.0 for WAVE Bioreactor can be used for data acquisition of the cultivation.

Main features

The main features of the WAVE Bioreactor system family are:

- Gamma irradiated, single-use Cellbag bioreactors that protect against the risk of cross-contamination, require no cleaning, and involve minimal validation.
- Cellbag bioreactors are supplied ready-for-use, minimizing the time for preparation. The Cellbag bioreactors are suitable for GMP commercial production without the use of a biosafety cabinet.
- No cell shear by sparged air bubbles.
- Suitable for suspension, microcarrier, batch, fed-batch and perfusion culture applications.
- Multiple configurations for control of parameters, such as pH and dissolved oxygen (DO).

- Scalable systems capable of handling culture volumes from 0.1 L in WAVE Bioreactor 2/10 to 500 L in WAVE Bioreactor 500/1000.
 - Up to 1:10 expansion during one cultivation.
 - Built-in temperature control.
-

Terminology for pH and DO in this manual

The terms...	refers to...
pH sensor and pHOPT sensor	the optical pH sensor used in Cellbag.
pH control and pHOPT control	pH control by WAVEPOD II.
DO sensor and DOOPT II sensor	the optical DO sensor used in Cellbag.
DO control and DOOPT II control	DO control by WAVEPOD II.

Note: *The suffix "II" in DOOPT II refers to the new patch-type DOOPT sensor integrated into some Cellbag bioreactors, as opposed to the older external probe format DOOPT sensor. For the WAVEPOD II instrument the term DOOPT is still used.*

Applications

The WAVE Bioreactor family can be used for cell expansion, recombinant protein, virus or vaccine production and high containment applications. Mammalian, insect, plant and microbial cell cultivations can be performed; in either suspension or on microcarriers.

Options

A range of optional controllers, pumps, and sensors allow the culture conditions within the Cellbag bioreactor to be monitored, maintained, and adjusted as necessary.

The optional WAVEPOD II controller integrates instrumentation associated with WAVE Bioreactor 20/50. This includes pH, dissolved oxygen, and CO₂/O₂ gas mixing controls.

1.4 WAVE Bioreactor 20/50 user documentation

Introduction

This section describes the user documentation that is delivered with the WAVE Bioreactor system.

User documentation

Document	Main contents
WAVE Bioreactor 20/50 and WAVEPOD II Operating Instructions	All instructions needed to run the WAVE Bioreactor instrument, including, for example, installation, descriptions of the features, operation and maintenance.
UNICORN DAQ Help (if UNICORN DAQ is included)	Dialog descriptions for UNICORN DAQ (from the Help menu).
UNICORN DAQ 1.0 user documentation (if UNICORN DAQ is included)	Overview and detailed descriptions of the features in UNICORN DAQ. Instructions on how to use the software. Workflow descriptions for common operations. Network setup and complete software installation. Administration of UNICORN DAQ and the UNICORN DAQ database.

1.5 Associated documentation

Data Files and Application Notes

To order or download produced data files and application notes, see the instruction below.

Step	Action
1	Go to www.gelifesciences.com/wave .
2	Click Literature under Related information .
3	Select to download or order chosen literature.

Other

For further information about optional stand-alone instruments, refer to *Stand-alone instruments for WAVE Bioreactor 2/10 and 20/50 Operating Instructions* or contact a GE Healthcare representative.

2 Safety instructions

About this chapter

This chapter describes safety compliance, safety labels, general safety precautions, emergency procedures, power failure and recycling of WAVE™ instruments.

In this chapter

This chapter contains the following sections:

Section	See page
2.1 Safety precautions	18
2.2 Labels	26
2.3 Emergency procedures	28
2.4 Recycling procedures	30
2.5 Declaration of Hazardous Substances (DoHS)	31

2.1 Safety precautions

Introduction

Before installing, operating or maintaining the system, you must be aware of the hazards described in this manual. Follow the instructions provided to avoid personal injury or damage to the equipment. The safety precautions in the section are grouped into the following categories:

- General precautions
 - Personal protections
 - Installing and moving the instrument
 - System operation
 - Maintenance
-

General precautions



WARNING

Do not operate the WAVE systems in any other way than described in the WAVE user documentation.



WARNING

Operation and user maintenance of the WAVE system should be performed by properly trained personnel only



WARNING

Do not use any accessories not supplied or recommended by GE Healthcare.



WARNING

Only Cellbag bioreactors approved by GE Healthcare for WAVE may be used on the equipment.

Using Flammable Liquids



WARNING

WAVE Bioreactor is not designed to handle flammable fluids.
WAVE Bioreactor is not approved for work in a potentially explosive atmosphere.

Using hazardous chemicals or biological reagents



WARNING

When using hazardous chemicals or biological agents, take all suitable protective measures, including appropriate precautions to accommodate for the remote risk of Cellbag bioreactor leakage.

Personal protection



WARNING

Always use appropriate personal protective equipment during operation and maintenance of WAVE systems.



WARNING

Hazardous substances. When using hazardous chemical and biological agents, take all suitable protective measures, such as wearing protective glasses and gloves resistant to the substances used. Follow local and/or national regulations for safe operation and maintenance of the system.

2 Safety instructions

2.1 Safety precautions



WARNING

Spread of biological agents. The operator has to take all necessary actions to avoid spreading hazardous biological agents in the vicinity of the instrument. The facility should comply with the national code of practice for biosafety.

Installing and moving the instrument



WARNING

Emergency stop. Position the WAVE system so that the power switch is easily accessible for power shut off. The power switch is located at the rear of the instrument.



WARNING

Protective ground. The WAVE instruments must always be connected to a grounded power outlet.



WARNING

Heavy object. Filled Cellbag bioreactor have a considerable weight and heavy lifts must be done with care. Use 1 person per multiple of 15 kg weight, for example 3 persons for 30 to 45 kg. All lifting and moving must be performed in accordance with local regulations.



WARNING

Disconnect power. Always disconnect power from the instrument before connecting the WAVE Bioreactor instrument or WAVEPOD II to any other instrument.

**CAUTION**

Disconnect all tubing, hoses and cables before moving the WAVE instrument.

**CAUTION**

Ensure that all tubing, hoses and cables are placed so that the risk for tripping accidents is minimized.

**CAUTION**

Make sure that there is enough free space around the instrument for the rocking motion.

**CAUTION**

The safety switches of the WAVE instrument must be functionally tested after the installation of the equipment or after the instrument has been transported and every 6 months from then on. See *Chapter 9 Maintenance, on page 223* for proper method of testing.

**CAUTION**

To avoid overheating, do not operate the heater for more than a few minutes without a filled Cellbag bioreactor on the Rocker tray.

System operation

**WARNING**

Biohazard. Make sure that the Cellbag bioreactor is sealed before and during the culture process.

2 Safety instructions

2.1 Safety precautions



WARNING

Electrical shock hazard after spillage. If there is a risk that large volumes of spilled liquid may penetrate the casing of the WAVE instrument, immediately switch off the instrument, disconnect the power cord, and contact an authorized service engineer.



WARNING

To prevent any gas leakage from the stand-alone instrument CO2MIX20, always switch off the CO₂ supply when not used. During cultivation using CO2MIX20, make sure that the room is well ventilated.



WARNING

To prevent any gas leakage from the stand-alone instrument O2MIX20, always switch off the O₂ supply when not used. During cultivation using O2MIX20, make sure that the room is well ventilated.



WARNING

If nitrogen is connected to the **AIR IN** there may be a leakage of nitrogen inside WAVEPOD II during normal use, even if there is no gas flow to the instrument. Make sure that the room is well ventilated and that the nitrogen is shut off when not needed.



WARNING

Do not inflate the Cellbag bioreactor with any other device than the internal airpump. This has an automatic overpressure shutdown that will prevent overpressure. Direct connection to a gas source or use of any other pump may result in rupture of the Cellbag bioreactor.



CAUTION

Pressure at the **Air In** port of WAVE Bioreactor must not exceed 0.1 bar. Exceeding this limit may cause rupture of the Cellbag bioreactor. Provide suitable safety pressure relief equipment.



CAUTION

Pinch hazard. Remain clear of all moving parts during operation. Stop the rocking motion before working on the Cellbag bioreactor or Rocker tray.



CAUTION

Overheating is possible if the instrument is operated without a liquid-containing bag. Do not touch a potentially overheated Rocker tray.



CAUTION

Leakage risk of biological substances. Before every use, check all hoses for signs of cracking or tears. None of the air hoses should contain liquids of any kind.



CAUTION

Remove any spillage on the floor immediately to minimize the risk for slipping accidents.



CAUTION

Use only chemicals that have been proven not to be harmful to the Cellbag bioreactor and the system.



CAUTION

When connecting gas to the equipment, ensure that the correct gas, gas quality and gas pressure are used to avoid hazards or undesired effects on the culture.

2 Safety instructions

2.1 Safety precautions



NOTICE

Ensure that the tubing is unobstructed and that gases can pass freely through the tubing.

Maintenance



WARNING

Electrical shock hazard. All repairs should be done by service personnel authorized by GE Healthcare. Do not open any covers or replace parts unless specifically stated in the user documentation.



WARNING

Disconnect power. Always disconnect power from the instrument before performing any work or maintenance task on the instrument.



WARNING

Always clean the equipment in a well ventilated area. Never douse or immerse any part of the instrument with any liquid. When cleaning is required, use only water and alcohol. Always ensure that the instrument is completely dry before plugging it in. Make sure to follow all environmental, health, and safety guidelines pertaining to the materials used.



WARNING

Only spare parts that are approved or supplied by GE Healthcare may be used for maintaining or servicing the system.



CAUTION

Water should not be applied directly to the instrument.

**CAUTION**

Do not connect power to the instrument until it is completely dry.

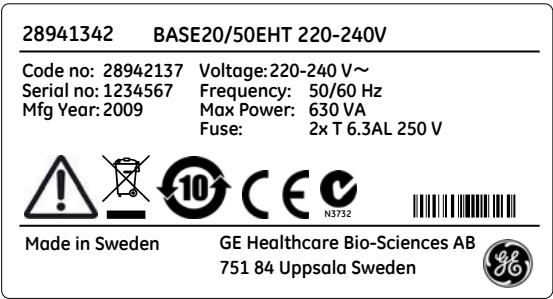
2.2 Labels

This section describes safety labels and labels concerning hazardous substances that are attached to the WAVE instruments.

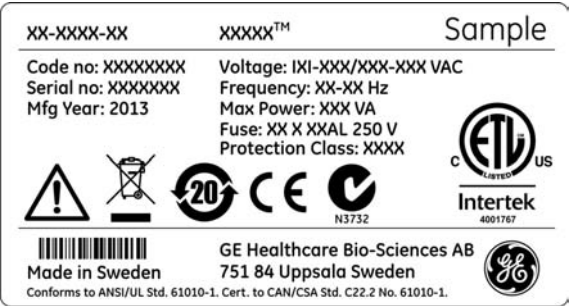
Labels on the instrument

The illustration below shows an example of the identification label that is attached to the WAVE instruments.

WAVE Bioreactor



WAVEPOD II



Symbols used in safety labels

Label	Description
	Warning! Read the user documentation before using the system. Do not open any covers or replace parts unless specifically stated in the user documentation.

Label	Description
	The system complies with applicable European directives.
	The system complies with the requirements for electromagnetic compliance (EMC) in Australia and New Zealand.
	This symbol indicates that WAVEPOD II has been certified by a Nationally Recognized Testing Laboratory (NRTL). NRTL means an organization, which is recognized by the US Occupational Safety and Health Administration (OSHA) as meeting the legal requirements of Title 29 of the Code of Federal Regulations (29 CFR), Part 1910.7.
	Indicates that there is a risk for body parts getting caught between two parts of the instrument and that care must be taken to avoid injury.

Labels concerning hazardous substances

Label	Properties
	This symbol indicates that the waste of electrical and electronic equipment must not be disposed as unsorted municipal waste and must be collected separately. Please contact an authorized representative of the manufacturer for information concerning the decommissioning of equipment.
	This symbol indicates that the product contains hazardous materials in excess of the limits established by the Chinese standard SJ/T11363-2006 Requirements for Concentration Limits for Certain Hazardous Substances in Electronics.

2.3 Emergency procedures

Introduction

This section describes how to do an emergency shutdown of a WAVE instrument. The section also describes the result in the event of power failure.

Safety switches

White rubber safety switches are located below the Rocker tray. If either of the safety switches is hit, the rocking motion stops and the Rocker tray moves to a level position.



If a safety switch has been hit, power must be turned off (O) and on (I) to reset the safety switch.

Emergency procedures

In an emergency situation, do as follows to stop the run:

Step	Action
1	Switch off the power to the instrument by pressing the power switch to the O position.
2	If required, disconnect the power cord from the power outlet.

Reset the Safety switch

To reset the safety switch:

- Turn off the power to the instrument by pressing the power switch to the **O** position.
 - Turn on the power to the instrument by pressing the power switch to the **I** position.
-

Power failure

In the event of power failure, the run is immediately interrupted. If the **AUTOSTART** option is set to **ON**, the operation is automatically resumed on power up. For troubleshooting, see *Section 10.1 General problems, on page 236*.

2.4 Recycling procedures

The equipment shall be decontaminated before decommissioning and all local regulations shall be followed with regard to scrapping of the equipment.

Disposal, general instructions

When taking WAVE Bioreactor systems out of service, the different materials must be separated and recycled according to national and local environmental regulations.

Recycling of hazardous substances

WAVE Bioreactor systems contain hazardous substances. Detailed information is available from your local GE Healthcare representative.

Disposal of electrical components

Waste of electrical and electronic equipment must not be disposed as unsorted municipal waste and must be collected separately. Please contact an authorized GE Healthcare representative for information concerning the decommissioning of your equipment.



2.5 Declaration of Hazardous Substances (DoHS)

Introduction

The following product pollution control information is provided according to SJ/T11364-2006 Marking for Control of Pollution caused by Electronic Information Products.

根据SJ/T11364-2006《电子信息产品污染控制标识要求》特提供如下有关污染控制方面的信息

Symbols used in pollution control label

电子信息产品污染控制标志说明

Label	Meaning
	This symbol indicates the product contains hazardous materials in excess of the limits established by the Chinese standard SJ/T11363-2006 Requirements for Concentration Limits for Certain Hazardous Substances in Electronic Information Products. The number in the symbol is the Environment-friendly Use Period (EFUP), which indicates the period during which the toxic or hazardous substances or elements contained in electronic information products will not leak or mutate under normal operating conditions so that the use of such electronic information products will not result in any severe environmental pollution, any bodily injury or damage to any assets. The unit of the period is "Year". In order to maintain the declared EFUP, the product shall be operated normally according to the instructions and environmental conditions as defined in the product manual, and periodic maintenance schedules specified in Product Maintenance Procedures shall be followed strictly. Consumables or certain parts may have their own label with an EFUP value less than the product. Periodic replacement of those consumables or parts to maintain the declared EFUP shall be done in accordance with the Product Maintenance Procedures. This product must not be disposed of as unsorted municipal waste, and must be collected separately and handled properly after decommissioning.
	

Label	Meaning
	该标志表明本产品含有超过SJ/T11363-2006《电子信息产品中有毒有害物质的限量要求》中限量的有毒有害物质。标志中的数字为本产品的环保使用期，表明本产品在正常使用的条件下，有毒有害物质不会发生外泄或突变，用户使用本产品不会对环境造成严重污染或对其人身、财产造成严重损害的期限。单位为年。
	为保证所声明的环保使用期限，应按产品手册中所规定的环境条件和方法进行正常使用，并严格遵守产品维修手册中规定的期维修和保养要求。 产品中的消耗件和某些零部件可能有其单独的环保使用期限标志，并且其环保使用期限有可能比整个产品本身的环保使用期限短。应到期按产品维修程序更换那些消耗件和零部件，以保证所声明的整个产品的环保使用期限。 本产品在使用寿命结束时不可作为普通生活垃圾处理，应被单独收集妥善处理

List of hazardous substances and their concentrations

产品中有毒有害物质或元素的名称及含量

Indication for each major part if substance exceeds limit

Value	Meaning
O	Indicates that this toxic or hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement in SJ/T11363-2006. 表示该有毒有害物质在该部件所有均质材料中的含量均在SJ/T11363-2006 标准规定的限量要求以下
X	Indicates that this toxic or hazardous substance contained in at least one of the homogeneous materials used for this part is above the limit requirement in SJ/T11363-2006. - Data listed in the table represents best information available at the time of publication 表示该有毒有害物质至少在该部件的某一均质材料中的含量超出SJ/T11363-2006 标准规定的限量要求 - 此表所列数据为发布时所能获得的最佳信息

List of hazardous substances

Component name 部件名称	Hazardous substance 有毒有害物质或元素					
	Pb 铅	Hg 汞	Cd 镉	Cr6+ 六价铬	PBB 多溴联苯	PBDE 多溴二苯醚
28-9847-40 ¹	X	X	O	O	O	O
28-9847-41 ¹	X	X	O	O	O	O
28-9847-42 ¹	X	X	O	O	O	O
28-9413-41 ¹	X	O	O	O	O	O
28-9413-42 ¹	X	O	O	O	O	O
28-9413-43 ¹	X	O	O	O	O	O
28-9413-44 ¹	X	O	O	O	O	O
28-9413-45 ¹	X	O	O	O	O	O
28-9413-46 ¹	X	O	O	O	O	O
28-9413-47 ¹	X	O	O	O	O	O
28-9413-48 ¹	X	O	O	O	O	O
28-9413-49 ¹	X	O	O	O	O	O
28-9413-50 ¹	X	O	O	O	O	O
28-9413-51 ¹	X	O	O	O	O	O
28-9413-52 ¹	X	O	O	O	O	O
28-9413-53 ¹	X	O	O	O	O	O
28-9413-54 ¹	X	O	O	O	O	O
28-9413-55 ¹	X	O	O	O	O	O
28-9413-56 ¹	X	O	O	O	O	O
28-4115-26 ¹	X	O	O	O	O	X
28-9416-44 ¹	X	O	O	O	O	X

Component name 部件名称	Hazardous substance 有毒有害物质或元素					
	Pb 铅	Hg 汞	Cd 镉	Cr6+ 六价铬	PBB 多溴联苯	PBDE 多溴二苯醚
28-4115-27 ¹	X	O	O	O	O	X
28-9416-45 ¹	X	O	O	O	O	X
28-4115-28 ¹	X	O	O	O	O	X
28-9416-46 ¹	X	O	O	O	O	X
28-4115-30 ¹	X	O	O	O	O	X
28-9416-47 ¹	X	O	O	O	O	X
28-4115-34 ¹	O	O	O	O	O	O
28-4115-35 ¹	O	O	O	O	O	O
28-4115-37 ¹	O	O	O	O	O	O
28-4115-38 ¹	O	O	O	O	O	O

¹ The product has not been tested as per the Chinese standard SJ/T11363-2006 Requirements for Concentration Limits for Certain Hazardous Substances in Electronic Information Product.

3 System description

About this chapter

This chapter describes the features of WAVE Bioreactor 20/50.

In this chapter

This chapter contains the following sections:

Section	See page
3.1 Overview description	36
3.2 Functional description	39
3.3 Cellbag bioreactor	42
3.4 WAVEPOD II	47
3.5 WAVE Bioreactor system configuration	51

3.1 Overview description

System overview

A complete WAVE Bioreactor 20/50 system consists of:

- WAVE Bioreactor 20/50
- Rocker tray (ordered separately)
- Gamma irradiated disposable Cellbag bioreactor (ordered separately)
- WAVEPOD II (optional)
- Lid (optional)
- Stand-alone instruments (optional)
- pH and DO sensors (integrated into Cellbag bioreactors, optional)
- UNICORN DAQ software (optional)

Front view of WAVE Bioreactor 20/50

The illustration below shows the front of the WAVE Bioreactor 20/50 instrument with an installed Rocker tray.

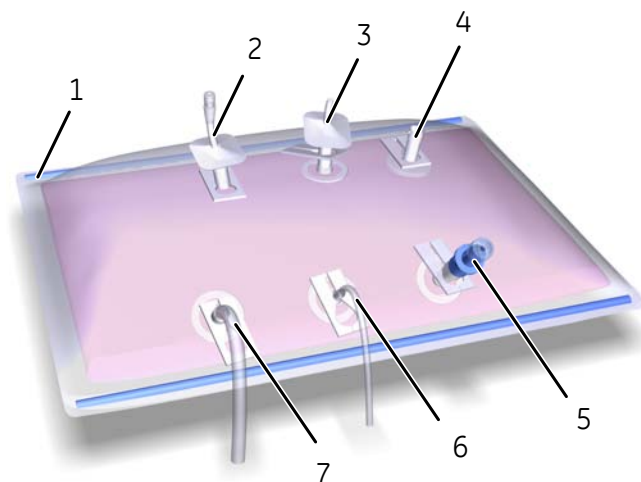


Part	Function
1	Protective bellows, rocking mechanism
2	Rocking platform
3	Rocker tray
4	Detachable touch screen

Illustration of Cellbag

The cell culture bag is provided in many different configurations; standard assortments and customized.

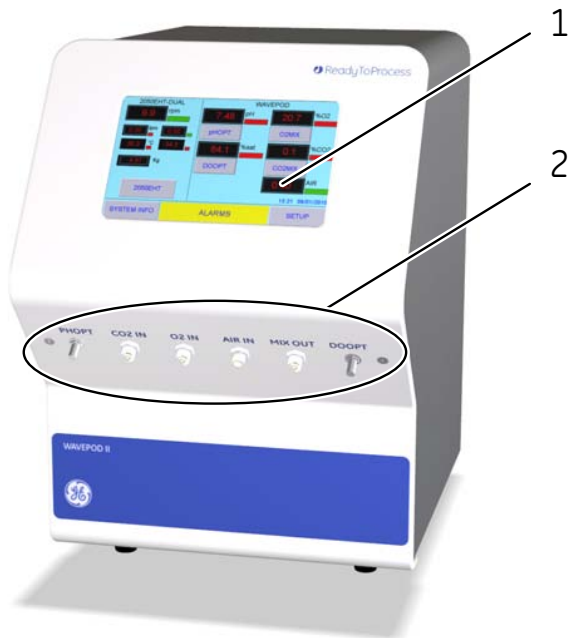
This illustration shows an example of a Cellbag configuration.



Part	Function
1	Cellbag rod
2	Outlet air filter
3	Inlet air filter
4	Spare Luer port
5	CLAVE™ needleless sampling port
6	Port for additions
7	Port for additions and harvest

Front view of WAVEPOD II

The optional WAVEPOD II controller monitors and controls culture parameters. The illustration below shows the front of the WAVEPOD II controller.



Part	Function
1	Touch screen
2	Connectors to sensor cables and gas tubing

Optional features

For information about other optional instruments, see *Section 3.5 WAVE Bioreactor system configuration, on page 51*.

For information about UNICORN DAQ, read the UNICORN DAQ 1.0 user documentation.

3.2 Functional description

Operating principle

The Cellbag bioreactor is placed on WAVE Bioreactor 20/50, is inflated with gas, partially filled with culture medium and is then inoculated with cells.

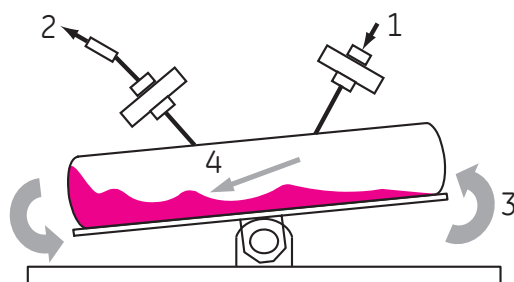
A wave motion is induced in the cultivation contained in the Cellbag bioreactor by the rocking mechanism. The wave motion mixes the fluid in the Cellbag bioreactor and suspends any cells and particles. The wave-induced agitation does not require an invasive mechanical mixer or gas sparging.

The wave motion also generates free surface for enabling effective oxygen transfer from the headspace of the bioreactor. Air is continuously passed through the bioreactor headspace in order to supply oxygen and remove metabolic waste gases.

Aeration is provided by an internal air pump and mass-flow controller. Alternatively, an optional gas mixer can be used.

Optionally, a WAVEPOD II controller is used to control pH, dissolved oxygen, airflow, and CO₂ and O₂ gas mixing.

Illustration of wave motion



Stage	Description
1	Air enters the Cellbag bioreactor through the inlet filter. It inflates the bag and provides oxygen to the culture.
2	Air and metabolic gases leave the Cellbag bioreactor through the outlet filter and pressure control valve. The pressure control valve ensures that a correct and constant overpressure is maintained inside the Cellbag bioreactor.
3	The rocking mechanism sets the rocking platform in motion.
4	Waves are formed during the rocking. The culture is cautiously mixed, and oxygen is transferred into the culture.

Control parameters

Available control parameters

Control of rocking, temperature and aeration are all available by default. Other control parameters depend on the system configuration.

Rocking control

The degree of mixing and oxygen transfer can be controlled by adjusting the rocking speed and angle.

Temperature control

Temperature is controlled by a heating plate that is placed between the rocking platform and the Rocker tray. A non-invasive temperature sensor is attached to the left side of the tray. The sensor cable plugs into a jack located on the side of the instrument. The cell culture bag is later placed on the Rocker tray.

Note: During dual operation, see Section 3.5 WAVE Bioreactor system configuration, on page 51, temperature sensors are used on both the left and right side, one for each bag.

Aeration

Air is drawn in by internal pumps inside WAVE Bioreactor and pumped into the headspace of the Cellbag bioreactor.

Alternatively, WAVEPOD II can provide aeration control.

CO₂ and O₂ gas concentration control

Air is drawn in by the internal pump from the inlet air port. O₂ or CO₂, if connected to their designated side panel ports, enables mixing of air with CO₂ and/or O₂ gas to a set concentration. This operation requires a CO₂ or O₂ configured WAVE Bioreactor 20/50 instrument.

Alternatively, the inlet air can be mixed with CO₂ and/or O₂ gas to a set concentration inside WAVEPOD II. The controlled gas mix is then connected directly to the Cellbag bioreactor, not via the WAVE Bioreactor instrument.

DO control

Dissolved oxygen (DO) can be measured with a WAVEPOD II in combination with an optical DO sensor integrated into the bottom of DOOPT II Cellbag configurations. The DO can be manually or automatically controlled via WAVEPOD II by changing the O₂ concentration for the air pumped into the Cellbag bioreactor or by changing the rocking speed. In addition, the rocking angle can be set manually.

pH control

pH can be measured using a WAVEPOD II in combination with an optical pH sensor integrated into the bottom of pHOPT Cellbag configurations. pH control is achieved by adding acid or base solution, or by adding base and controlling the CO₂ concentration for the air added to the Cellbag bioreactor. For addition of acid and/or base one additional pump is required per solution.

Perfusion control

Perfusion can be performed and controlled using a WAVE Bioreactor 20/50 version with integral load cell. Feed and harvest PUMP20 pumps are also required. Periodically during perfusion, fresh culture medium is added and cell-free culture media removed.

Instrument user interface

WAVE Bioreactor

WAVE Bioreactor is controlled by a touch screen located on the front of the instrument. The touch screen shows the current state of the system and can also be used to control the system. The touch screen can be detached from the instrument for more convenient operation. A cable connects the screen to the instrument. For detailed descriptions of the control functions, see *Chapter 5 WAVE Bioreactor control system*, on page 83.

WAVEPOD II

The optional WAVEPOD II controller displays system information on an integrated touch screen. For detailed descriptions of the control functions, see *Chapter 6 WAVEPOD II Control system*, on page 115.

3.3 Cellbag bioreactor

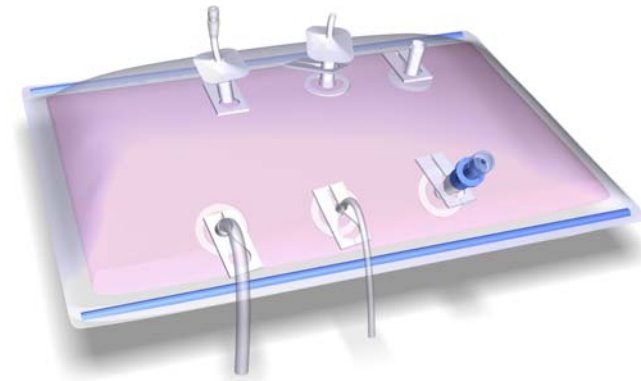
Introduction

Cell cultivation is performed inside the Cellbag bioreactor. The Cellbag bioreactor is delivered gamma irradiated and ready for use. It is intended for single use and must be discarded after use.

Please take a few moments to familiarize yourself with the features of the Cellbag bioreactor.

Illustration

Schematic illustration of a Cellbag bioreactor.



Description

Each Cellbag bioreactor is packed in two protective plastic bags. For Cellbag bioreactors that have optical pH and/or DO sensors, the inner bag is made of a black plastic that prevents the optical sensors from being exposed to light before use. The outer bag and its entire content have been gamma irradiated.

The Cellbag bioreactor itself consists of a multi layer film designed to provide strength, flexibility, excellent gas barrier performance and inert product contact. The fluid contact layer is made of ethylene vinyl acetate (EVA) and the outer layer consists of linear low density polyethylene (LLDPE). Proprietary composites provide strength and low gas permeability. All contact components meet USP Class VI specifications and all Cellbag bioreactors are lot tested for endotoxin.

Maximum operating pressure is 0.1 bar (1.5 psig), recommended operating pressure is 5 to 7.5 mbar (2 to 3 inches water).



NOTICE

The black inner protective bag is removed immediately before use. It should not be opened before you enter the production room.

Cellbag sizes

The following Cellbag bioreactor sizes are available for WAVE Bioreactor 20/50:

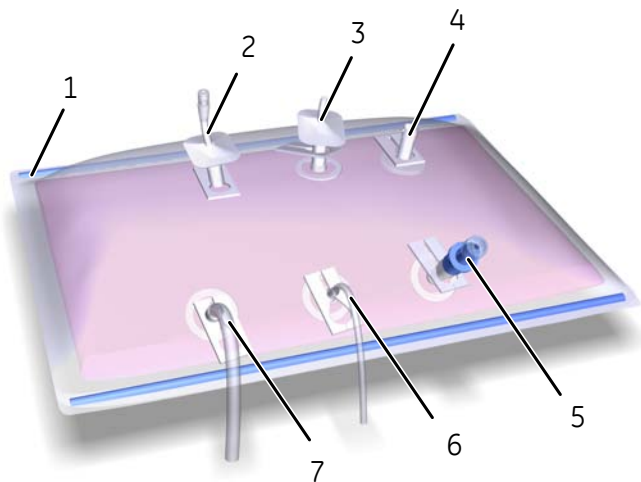
- 2 L
- 10 L
- 20 L
- 22 L
- 50 L

Selection guide

For cell culture volumes	Use Cellbag size
0.1 - 1 L	2 L
0.5 - 5 L	10 L
1 - 10 L	20 L or 22 L
5 - 25 L	50 L

Cellbag components

The cell culture bag is provided in many different configurations, standard assortments and customized. This illustration shows an example of a Cellbag bioreactor that has the following gamma irradiated components:



Part	Component	Description
1	Cellbag rod	Fixes the bag to the Rocker tray.
2	- Outlet air filter - Pressure control valve	- The hydrophobic outlet filter removes particles from the air vented from the bioreactor. This filter is rated to remove airborne particulates of 0.2 micron or larger, allowing for containment of the bioreactor contents. The composition of the filter membrane enables wet gases and condensate to pass without compromising filter functionality. - The pressure control valve is attached to the outlet air filter. The purpose of the pressure control valve is to maintain constant pressure in the bioreactor regardless of inlet airflow rate.

Part	Component	Description
3	Inlet air filter	The hydrophobic inlet filter removes particles from the air before the air is introduced into the Cellbag bioreactor. The filters used are rated to remove air-borne particulates of 0.2 micron or larger.
4	Luer ports	Additional luer ports may be present on the Cellbag bioreactor for additions.
5	CLAVE sampling port	This port is equipped with a self-sealing luer fitting for easy aseptic sampling using a needleless conventional syringe with luer connection.
6	Addition port	This port is equipped with a luer quick connector. Connection and disconnection should be done using proper aseptic procedures. Alternatively, a tube fuser may be used.
7	Addition/harvest port	This port is equipped with an MPC quick connector. Connection and disconnection should be done using proper aseptic procedures. Alternatively, a tube fuser may be used.
Not shown	ReadyMate™ connection	Cellbag bioreactors may be equipped with ReadyMate aseptic connectors for high fluid throughput connection.
Not shown	pHOPT port	pHOPT configured bags have a port with an optical pH sensor on the bottom of the bag.
Not shown	DOOPT II port	DOOPT II configured bags have a port with an optical DO sensor on the bottom of the bag.
Not shown	Tubing Connection	A length of tubing is provided for easy sterile connections using standard tube fusing devices. This tubing is terminated with a standard luer connector so that connections also can be made inside a laminar flow hood.

Part	Component	Description
Not shown	Options	Custom cell culture bags with variation of ports and their port components (tubing, connectors, etc.) can be manufactured for specific applications within the Cellbag design space.

Note: Cellbag bioreactors with internal cell retention filters for perfusion culture are available in several sizes.

Convenient after run procedures

The system has minimal turnaround time. The Cellbag bioreactor is in itself a convenient harvest container. The completed batch can be removed and a new Cellbag bioreactor be placed on the instrument.

In the event of product changeover or contamination, conventional bioreactors require time-consuming validated cleaning and decontamination. This can take several weeks during which the bioreactor cannot be used. In contrast, the WAVE Bioreactor system has minimal downtime. It also offers assurance against cross-contamination or product carryover.

3.4 WAVEPOD II

Introduction

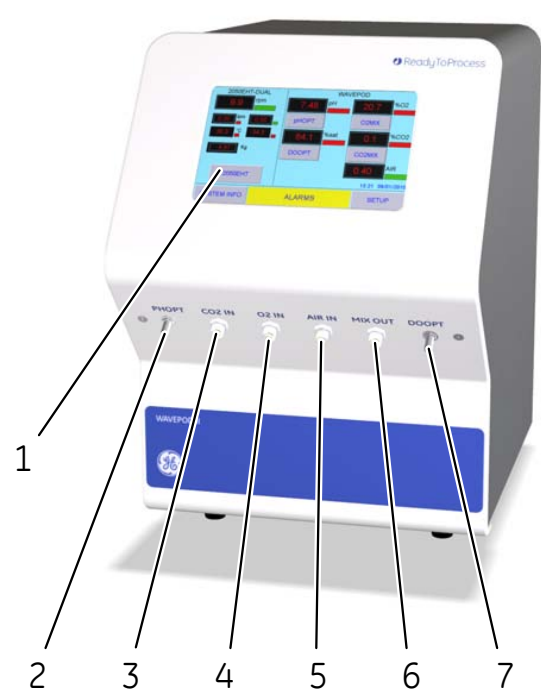
The WAVEPOD II controller integrates supporting instrumentation associated with WAVE Bioreactor 20/50. Depending on the configuration, the controls include all or some of the following: pH, dissolved oxygen, airflow, and CO₂ and O₂ gas mixing.

Many parameters of WAVE Bioreactor can be remote controlled from the WAVEPOD II Touch screen.

Dual WAVE Bioreactor 20/50 instruments can handle two Cellbag bioreactors, as described in *Rocker tray and Cellbag bioreactor, on page 53*. One WAVEPOD II is required for each Cellbag.

Illustrations of WAVEPOD II

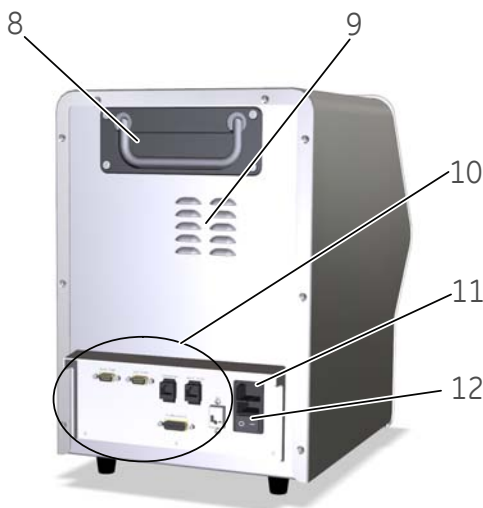
The illustration below shows the location of the main parts of the front of WAVEPOD II.



Part	Function
1	Touch screen

Part	Function
2	PHOPT connector
3	CO2 IN connector
4	O2 IN connector
5	AIR IN connector
6	MIX OUT connector
7	DOOPT II connector

The illustration below shows the location of the main parts of the back of WAVEPOD II.



Part	Function
8	Lifting handle
9	Ventilation
10	Connectors to instruments, pumps, computers
11	Power connector
12	Power switch

Available modules for WAVEPOD II

WAVEPOD II can be configured to have the following modules integrated. The modules are preinstalled at purchase.

Module	Description
pH controller	Enables on-line measurement of pH in the Cellbag bioreactor using an optical sensor and feed-back control with acid/base additions. The controller can operate WAVE PUMP20 units or user-supplied pumps. It can also control pH through changes in the CO ₂ composition of the inlet gas, if a CO ₂ controller is installed into WAVEPOD II.
DO (Dissolved Oxygen) controller	Enables on-line measurement of dissolved oxygen in the Cellbag bioreactor using an optical sensor and control via changes in rocking speed. It can also control DO through changes in the O ₂ composition of the inlet gas, if a O ₂ controller is installed into WAVEPOD II.
Airflow controller	Controls the flow of air through the Cellbag bioreactor using a thermal mass flow sensor and a flow control valve.
CO ₂ controller	Measures and controls the CO ₂ concentration in the inlet gas to the Cellbag bioreactor using an internal non-dispersive infrared (NDIR) sensor and an internal controller.
O ₂ controller	Measures and controls the O ₂ concentration in the inlet gas to the Cellbag bioreactor using an internal zirconium oxide sensor and an internal controller.

Note: The CO₂ or O₂ gas source should be pure, since impurities may affect the culture.

Main features

- Compact design provides all major parameter controls
- Large color touchscreen provides easy user access
- Integrates with WAVE Bioreactor 20/50 to provide a unified control unit with control capabilities
- Output for data acquisition, to, for example, UNICORN DAQ via an Ethernet converter
- Date-stamped alarms stored in non-volatile memory for easy troubleshooting

3 System description

3.4 WAVEPOD II

- Integrated control for optional, external acid/base pumps
 - Alarm contacts for chart recorders and remote monitoring systems
-

3.5 WAVE Bioreactor system configuration

Introduction

The WAVE Bioreactor systems provide scalable cell cultivation possibilities with control of key parameters. Several different configurations are available for enabling optimal user flexibility and control of some or all of these key parameters.

The control of the parameters can be performed by the following:

- Integrated modules in the WAVE Bioreactor instrument
- Integrated modules in the WAVEPOD II controller
- Separate stand-alone instruments

pH control alternatives and hardware requirements

The pH of the growth medium can be controlled in various ways, depending on the hardware installed with the WAVE Bioreactor instrument. pH can be controlled by the addition of acid or base via pumps, by controlling the CO₂ concentration, or a combination of the two. The following table outlines the hardware requirements for the various pH control methods.

Strategy for pH control	Instrument requirements
Indirect control by controlling the CO ₂ concentration	• WAVE Bioreactor with an integrated CO₂ control module, or • WAVEPOD II with CO₂ control module, or • CO2MIX20 (stand-alone instrument), or • CO2MIX20-R (stand-alone instrument)
Feed-back control with base addition to increase pH and acid addition to decrease pH	• WAVEPOD II with pHOPT control module and PUMP20 and a pHOPT configured Cellbag bioreactor Note: <i>Two PUMP20 pumps will be needed if both acid and base addition is required.</i>

Strategy for pH control	Instrument requirements
Feed-back control with base additions to increase pH and control of the CO ₂ concentration to decrease pH.	WAVEPOD II with pHOPT and CO₂ control modules, PUMP20 and a pHOPT configured Cellbag bioreactor.

In this manual, focus is on using WAVEPOD II for parameter controls. For further information about optional stand-alone modules, please refer to *Stand-alone instruments for WAVE Bioreactor 2/10 and 20/50 Operating Instructions* or www.gelifesciences.com/wave.

Optional controls

Several parameters can be controlled using optional instrumentation or configuration, see table below. For more information about the stand-alone instruments, see *Stand-alone instruments for WAVE Bioreactor 2/10 and 20/50 Operating Instructions* or www.gelifesciences.com/wave, or contact GE Healthcare.

Function	Product name	Location
Dissolved oxygen controller	DOOPT II	WAVEPOD II
CO2/air controller	CO2MIX20	WAVEPOD II or WAVE Bioreactor instrument or stand-alone instrument
CO2/air controller (rotameter model)	CO2MIX20-R	stand-alone instrument
O2/air controller	O2MIX20	WAVEPOD II or WAVE Bioreactor instrument or stand-alone instrument
O2/air controller (rotameter model)	O2MIX20-R	stand-alone instrument
Peristaltic feed/harvest or acid/base pump	PUMP20	stand-alone instrument
pH controller (when combined with PUMP20)	pHOPT	WAVEPOD II
Weight controller (can be used for perfusion)	LOADCELL20	WAVE Bioreactor instrument

Note: LOADCELL20 is pre-installed if the load cell option was ordered with WAVE Bioreactor 20/50. LOADCELL20 cannot be ordered separately

Note: UNICORN DAQ 1.0 is compatible with WAVEPOD II and LOADCELL20.

Rocker tray and Cellbag bioreactor

Several Cellbag bioreactor sizes are compatible with the WAVE Bioreactor 20/50 instruments, specific sizes depend on the rocker KIT used. This enables scale-up using the same instrument.

Configured versions of the WAVE Bioreactor 20/50 instrument enables dual operation, which is the use of two Cellbag bioreactors on one Rocker tray. In dual version, both the left and the right hand side panels have connectors for air and temperature sensors.

For WAVE Bioreactor 20/50 the following Rocker tray kits and bags can be used:

WAVE Bioreactor	Rocker tray kit	Cellbag bioreactor size
WAVE Bioreactor 20/50- single operation	KIT20EHT	• 2 L • 10 L • 20 L
WAVE Bioreactor 20/50- single operation	KIT50EHT	• 22 L • 50 L
WAVE Bioreactor 20/50- dual operation	KIT20EHTD	• 2 x 2 L • 2 x 10 L
WAVE Bioreactor 20/50- dual operation	KIT50EHTD	• 2 x 22 L
WAVE Bioreactor 20/50- single operation on dual Rocker tray kit	KIT20EHTD	• 20 L
WAVE Bioreactor 20/50- single operation on dual Rocker tray kit	KIT50EHTD	• 50 L

Tip: It is possible to place only one bag on the left side of a dual Rocker tray kit.

4 Installation

About this chapter

This chapter provides information regarding installation of WAVE Bioreactor 20/50, WAVEPOD II and UNICORN DAQ 1.0.

For further information on installation, refer to the user documentation listed in *Section 1.4 WAVE Bioreactor 20/50 user documentation, on page 15*.

In this chapter

This chapter contains the following sections:

Section	See page
4.1 Site requirements	55
4.2 Installation of WAVE Bioreactor 20/50	58
4.3 Transportation	71
4.4 Installation of WAVEPOD II	72
4.5 Connecting to UNICORN DAQ 1.0	80

4.1 Site requirements

Precautions



WARNING

If nitrogen is connected to the **AIR IN** there may be a leakage of nitrogen inside WAVEPOD II during normal use, even if there is no gas flow to the instrument. Make sure that the room is well ventilated and that the nitrogen is shut off when not needed.



WARNING

To prevent any gas leakage from the stand-alone instrument CO2MIX20, always switch off the CO₂ supply when not used. During cultivation using CO2MIX20, make sure that the room is well ventilated.



WARNING

To prevent any gas leakage from the stand-alone instrument O2MIX20, always switch off the O₂ supply when not used. During cultivation using O2MIX20, make sure that the room is well ventilated.



CAUTION

When connecting gas to the equipment, ensure that the correct gas, gas quality and gas pressure are used to avoid hazards or undesired effects on the culture.

Power requirement

Parameter	Requirement
Electrical power	110 to 120 V ~ or 220 to 240 V ~, 50/60 Hz

Site environment

Parameter	Requirement
Ambient temperature, WAVE Bioreactor 20/50	4°C to 40°C
Ambient temperature, WAVEPOD II	4°C to 40°C
Humidity, WAVE Bioreactor 20/50	< 95%, non-condensing
Humidity, WAVEPOD II	10% to 90%, non-condensing

Note: *The ambient temperature must be at least 5°C lower than the desired culture growth temperature for satisfactory temperature control.*

Requirements on placement

- The bench must be stable and withstand vibration from the rocking.
- The bench must be able to bear the total weight of the instrument, WAVEPOD II (if used), and the filled Cellbag bioreactor. See *Section A.1 Specifications, on page 252* for instrument specifications. If other optional instruments are installed, their weights must also be included, see separate specifications.
- At least 25 cm workspace must be available on either side of WAVE Bioreactor for safety and ease of access, and at least 10 cm in front and behind for adequate ventilation.
- Do not place soft material under WAVE Bioreactor or WAVEPOD II. It may block the ventilation inlet.



NOTICE

When using Cellbag bioreactors with built-in optical sensors, such as pHOPT or DOOPT II sensors, WAVE Bioreactor should be placed away from intense light such as direct sunlight. Intense light will deteriorate the optical sensors.

Optional utilities

Parameter	Requirement
CO ₂ , 100%	1.5 slpm at 0.7 to 1.0 bar (10 to 15 psig). Minimum delivery 0.2 lpm.

Parameter	Requirement
O ₂	5.0 slpm at 0.7 to 1.0 bar (10 to 15 psig). Minimum delivery 0.2 lpm.
AIR IN supply	0.1 to 0.2 bar (1 to 3 psig)

Tip: Ambient or process air can be used. However, ensure that the maximum pressure listed above is not exceeded.

Tip: It is possible to produce an oxygen mixture with concentrations below 21% (air), by connecting a nitrogen stream to the **AIR IN** port (< 0.2 bar or 3 psig) on WAVEPOD II.

4.2 Installation of WAVE Bioreactor 20/50

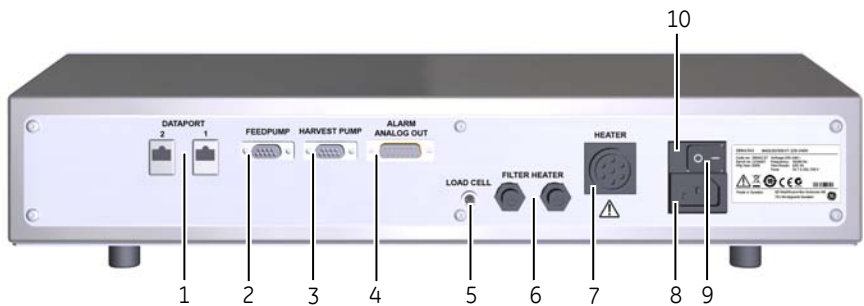
Unpacking

Unpack the equipment and place it on a stable surface.

Check the equipment for any apparent damage before starting installation. Document any damage carefully and contact your GE Healthcare representative.

WAVE Bioreactor 20/50 rear panel

The illustration below shows the rear panel of WAVE Bioreactor 20/50.



Part	Function
1	DATAPORT1 and 2
2	FEED PUMP port
3	HARVEST PUMP port
4	ALARM ANALOG OUT port
5	LOAD CELL port
6	FILTER HEATER ports
7	HEATER port
8	Power port
9	Power switch
10	Fuse holder

WAVE Bioreactor 20/50 side panel

The illustration below shows the side panel of WAVE Bioreactor 20/50.

Note: In dual versions of the instrument, several ports are provided on a side panel on the right hand side.



Part	Function
1	Temp port
2	Air Out port
3	Air In port

Installation of the Rocking plate

Follow the instruction below to install the Rocking plate.



WARNING

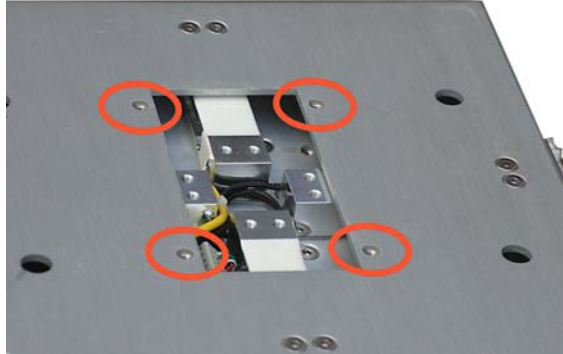
Disconnect power. Always disconnect power from the instrument before performing any work or maintenance task on the instrument.

4 Installation

4.2 Installation of WAVE Bioreactor 20/50

Step	Action
------	--------

- | | |
|---|---|
| 1 | Identify the four mounting holes on the instrument. |
|---|---|



- | | |
|---|---|
| 2 | Place the Rocking plate onto the bioreactor instrument and align the four mounting holes. Make sure that the opening for cables is on the left when facing the front of the bioreactor. |
|---|---|



- | | |
|---|--|
| 3 | Fasten the Rocking plate by screwing the four mounting screws through the mounting holes using an Allen key. |
|---|--|

Rocker tray kit

KIT20EHT(D) or KIT50EHT(D) are used with the WAVE Bioreactor 20/50 instrument. Each kit includes the hardware required to properly mount a Cellbag bioreactor, and a Heater pad to control the operating temperature.

Note: In the rocker kit names, the abbreviation EH stands for 'electrically heated', T for 'touch screen' and D for 'dual'.

Setting up the Rocker tray and temperature control system

Follow the instruction below to set up the temperature control system. This includes installing the Rocker tray.



WARNING

Disconnect power. Always disconnect power from the instrument before performing any work or maintenance task on the instrument.

Step	Action
1	Place the Heater pad on the Rocking plate. Make sure that the Heater pad is oriented with the white side up and with the power connector fitting into the slot on the left side of the Rocking plate.



- | Step | Action |
|------|---|
| 2 | Plug the blue heater cable into the rear panel port labeled HEATER . |



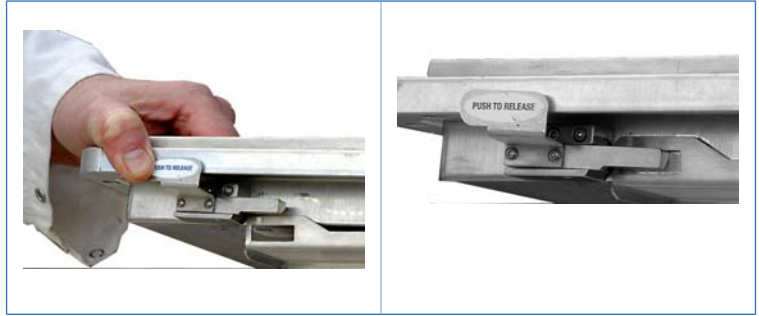
- | | |
|---|---|
| 3 | Place the stainless steel Rocker tray on top of the Heater pad. |
|---|---|



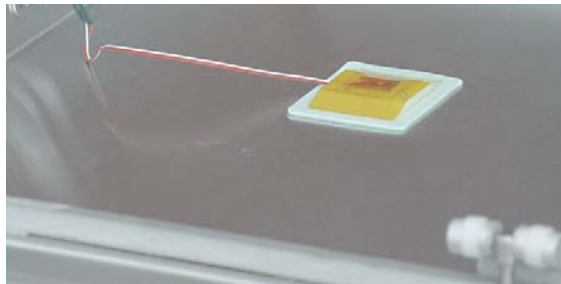
- | | |
|---|---|
| 4 | Slide the Rocker tray towards the back and ensure the tabs are engaged. |
|---|---|

Step	Action
------	--------

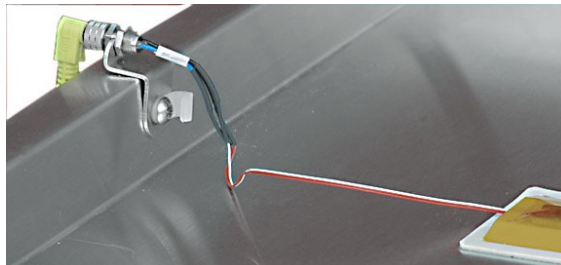
- | | |
|---|--|
| 5 | Push the front down while pushing the Push for release lock, so that the right and left catches engage. |
|---|--|



- | | |
|---|---|
| 6 | Make sure that the SRTDX temperature sensor is positioned properly in the SRTDX retainer. |
|---|---|



- | | |
|---|--|
| 7 | Carefully connect the yellow temperature sensor cable to the Temp port on the left side of the Rocker tray. |
|---|--|



4 Installation

4.2 Installation of WAVE Bioreactor 20/50

Step	Action
8	Connect the other end of the cable into the temperature sensor port on the left side panel. Screw the locking nuts to firmly secure the plugs.



- | | |
|----|--|
| 9 | Check that the temperature display on the main screen reads the ambient temperature. |
| 10 | <i>For dual-sided operation:</i> Connect another yellow temperature sensor cable to the temperature sensor port on the left side of the Rocker tray. Connect the other end of the cable into the SRTDX temperature sensor port on the right side panel. Screw the locking nuts to firmly secure the plugs. |

Change trays



WARNING

Disconnect power. Always disconnect power from the instrument before performing any work or maintenance task on the instrument.

To change Rocker trays:

- Remove the current tray from the Rocking plate by pushing the **Push for release** catches and lifting up the tray in the front. Then lift up the rear part of the tray.
- Fit a new tray as above.



Connecting power

Follow the instruction below to connect power to the bioreactor.

Step	Action
------	--------

- | | |
|---|--|
| 1 | Connect the supplied power cord to the power inlet on the rear panel and to a grounded power outlet. |
|---|--|



- | | |
|---|--|
| 2 | Press the power switch on the rear panel to the I position to turn on the instrument. |
|---|--|

Result: The Touch screen lights up and the instrument starts. The instrument tilts to its home position and when initialization is completed the main screen is displayed.



CAUTION

Make sure that there is enough free space around the instrument for the rocking motion.

Setting up the aeration system
of the bioreactor

Cellbag bioreactors require aeration to keep them inflated and to provide gas for oxygenation and pH control. The air inlet gas can be room air, incubator air, or a special gas mixture, depending on the cell line and buffer system in use.

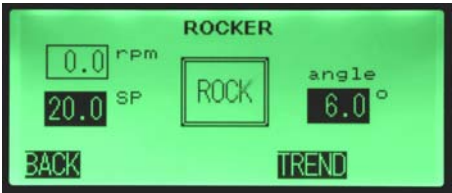
The WAVE Bioreactor 20/50 instrument has an internal air pump (two in the dual version) that is used to aerate the Cellbag bioreactors.

For information about setting up the aeration system, see *Section 8.4 Connect aeration, on page 185*.

Verification of rocking function

Follow the instruction below to verify that the rocking action operates correctly.

Step	Action
1	Turn on WAVE Bioreactor and wait for the system to initialize.
2	On the MAIN screen, press the ROCKER button. <i>Result:</i> The ROCKER control screen opens, see <i>Section 5.2.1 Rocking control, on page 88</i> .



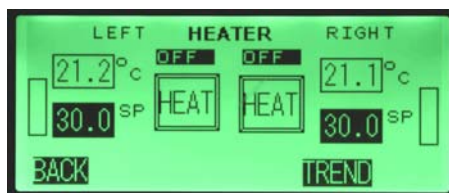
3	Press the speed SP (setpoint) box and enter 20.0 as the new setpoint value using the data entry keypad. Press ↵ to return to the ROCKER control screen.
4	Press the ROCK button. <i>Result:</i> WAVE Bioreactor should start rocking and the ROCK button should be replaced by a STOP button.
5	Ensure that the rocking operates at the correct speed. Try a few different rocking speeds.
6	While the Rocker tray is moving, open the ROCKER control screen by pressing the ROCKER button.
7	Change the rocking angle by pressing the black angle box and entering a new value. Ensure that the rocking angle changes.

Step	Action
8	If the rocking speed or rocking angle do not appear to be correct, refer to <i>Section 10.1 General problems, on page 236</i> .
9	Stop the rocking by pressing the STOP button and return to the MAIN menu using the BACK button.

Verification of temperature control function

Follow the instruction below to verify that the temperature control system is functioning correctly.

Step	Action
1	Turn on WAVE Bioreactor and wait for the system to initialize.
2	Ensure that the temperature display on the MAIN screen reads the ambient temperature.
3	in the MAIN screen, press the HEATER button. Result: The HEATER control screen opens, see <i>Section 5.2.5 Temperature control, on page 94</i> .



Note:

For Dual operation, both heaters should be verified according to these instructions.

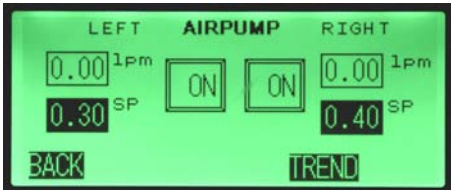
4	Press the temperature SP box and enter 40.0 as the new value using the data entry keypad. Press ↵ to return to the HEATER control screen.
---	---

Step	Action
5	Press the HEAT button. The bar graph should increase showing that the heater(s) are on and the Rocker tray should start warming up. Note: <i>The Rocker must be in motion for the heating to start. Heat will not be applied to a motionless Rocker to avoid local overheating in the Cellbag bioreactor.</i>  CAUTION To avoid overheating, do not operate the heater for more than a few minutes without a filled Cellbag bioreactor on the Rocker tray.
6	Verify the heater interlock by unplugging the heater pad power cable. This should cause a HEATER FAULT alarm.
7	Reattach the heater pad power cable. The heater should resume operation.
8	Verify the temperature sensor by unplugging the SRTDX temperature sensor cable. The heater should turn OFF and an alarm should be triggered.
9	Reattach the SRTDX temperature sensor cable. Correct operation should resume in a few seconds.
10	If the temperature control system does not appear to be functioning correctly, refer to <i>Section 10.1 General problems, on page 236</i>.
11	Turn the heater(s) off and return to the MAIN screen by pressing the BACK button.

Verification of aeration system

Follow the instruction below to verify that the aeration system operates correctly.

Step	Action
1	Connect air tubing to the Air Out port on the side panel of WAVE Bioreactor. Turn on WAVE Bioreactor and wait for the system to initialize.

Step	Action
2	In the MAIN screen press the AIR button. <i>Result:</i> The AIRPUMP control screen opens, see Section 5.2.6 Aeration control, on page 96. 
	Note: <i>For Dual operation, both left and right air pumps should be verified according to these instructions.</i>
3	Press the air SP (setpoint) box and enter 0.50 as the new setpoint using the data entry keypad. Press ↵ to return to the AIRPUMP control screen.
4	Press the ON button. The air pump should turn on and the airflow increase and hold at the setpoint.
5	Verify that the overpressure alarm is functional by pinching shut the Air Out tubing. <i>Result:</i> After about 30 seconds an overpressure alarm should be activated and the air pump should shut down automatically.
6	Turn the air pump off by pressing the OFF button.
7	If the air pump does not operate correctly, refer to Section 10.1 General problems, on page 236.

Setting the clock

All alarm data is labeled with the current date and time. It is therefore important to set the clock to the local time.

Follow the instruction below to set the real time clock.

Step	Action
1	On the main screen, press MENU .
2	On the MENU screen, press SETUP .
3	Enter the password "2050".
4	On the SETUP screen, press SET CLK .

Step	Action
5	Change the date and time as needed. Press ↵ to accept each entry.
6	Press SET to accept the new date and time or BACK to abort. <i>Result:</i> The main screen is displayed.

Optional weight sensor

The optional loadcell is mounted under the Rocker tray and provides the weight of the Rocker tray kit plus the Cellbag bioreactor. It can be used for weight measurements, fill/harvest and perfusion control. Jacks located at the rear of the WAVE Bioreactor 20/50 instrument can be used to control feed and harvest pumps.

Setting up the optional weight sensor

If the load cell option was ordered with the WAVE Bioreactor 20/50 instrument, then it should already be installed.

Follow the instruction below to connect the weight sensors to the instrument and verify function:

Step	Action
1	Connect the yellow 4-pin cable from the LCELL20/50EHT to the jack LOAD CELL located at the rear of the WAVE Bioreactor 20/50 instrument.
2	In the main screen press WEIGHT . <i>Result:</i> The WEIGHT screen opens.
3	Push down on the Rocker tray with your hands and verify that the displayed weight increases.
4	If the load cell does not operate properly, see <i>Section 10.2 Module specific problems, on page 244</i> .

4.3 Transportation

Moving WAVE Bioreactor 20/50

Follow the instruction below to move WAVE Bioreactor 20/50.

Step	Action
1	Disconnect the instrument from the power source.
2	Remove the Rocker tray. The instrument should be moved without liquid on top.
3	Lift the instrument by the lifting handles. The instrument should be moved by two persons.
4	If installing the instrument in a new location, refer to the safety instructions and following sections for installation procedures.

4.4 Installation of WAVEPOD II

Introduction

This section describes the installation of WAVEPOD II for use with WAVE Bioreactor.

Note: *WAVEPOD II should be physically installed next to WAVE Bioreactor or as close as possible. Excessive lengths of connecting tubing will activate the WAVEPOD II overpressure alarms.*

For information about installation and connection of stand-alone instruments for use with WAVE Bioreactor 20/50, see *Stand-alone instruments for WAVE Bioreactor 2/10 and 20/50 Operating Instructions*.



WARNING

Disconnect power. Always disconnect power from the instrument before connecting the WAVE Bioreactor instrument or WAVEPOD II to any other instrument.



NOTICE

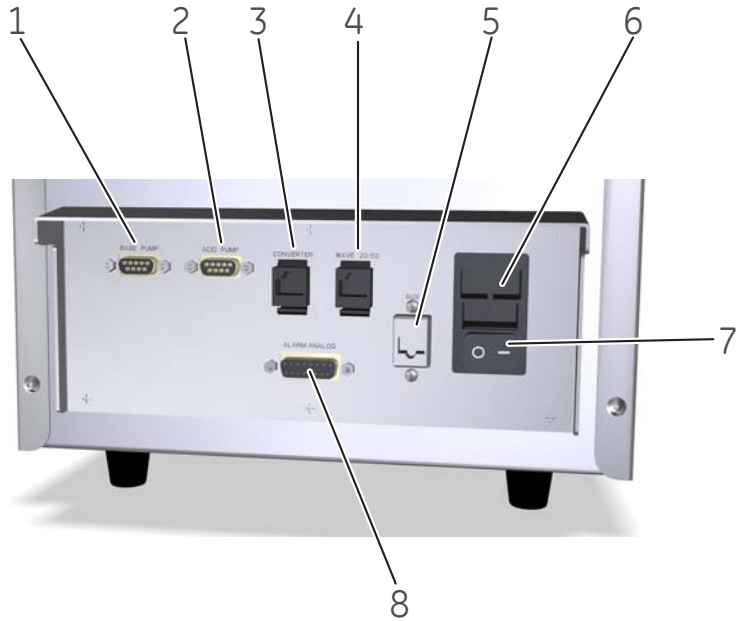
Do not place WAVEPOD II next to a heating register, air duct or in direct sunlight as control operations may be affected.

Unpacking

Unpack the equipment and place it on a stable surface.

Check the equipment for any apparent damage before starting installation. Document any damage carefully and contact your GE Healthcare representative.

WAVEPOD II rear panel



Part	Function
1	BASE PUMP connector
2	ACID PUMP connector
3	CONVERTER connector
4	WAVE 20/50 connector
5	AUX connector
6	POWER connector
7	Power switch
8	ALARM/ANALOG connector



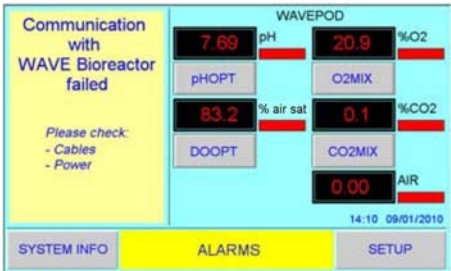
NOTICE

The **AUX** connector is only to be used by GE Healthcare service personnel.

Connecting power

Follow the instruction below to connect power to WAVEPOD II.

Step	Action
1	Connect WAVEPOD II to a grounded power outlet. The power connector is located on the rear of the instrument.
2	Turn on the power to WAVEPOD II by pressing the power switch located on the rear panel to the I position. <i>Result:</i> The MAIN MENU screen opens. A communication error message is displayed until a WAVE Bioreactor is connected to WAVEPOD II.



NOTICE
The mains power must be turned off to WAVEPOD II before connecting any external unit.

Connecting to
WAVE Bioreactor 20/50



NOTICE
Once WAVEPOD II is connected to WAVE Bioreactor 20/50, do not connect any other instrument to the second dataport on the WAVE Bioreactor 20/50 instrument, as the communication protocol will be violated.

Follow the instruction below to connect WAVEPOD II to a WAVE Bioreactor instrument.

Step	Action
------	--------

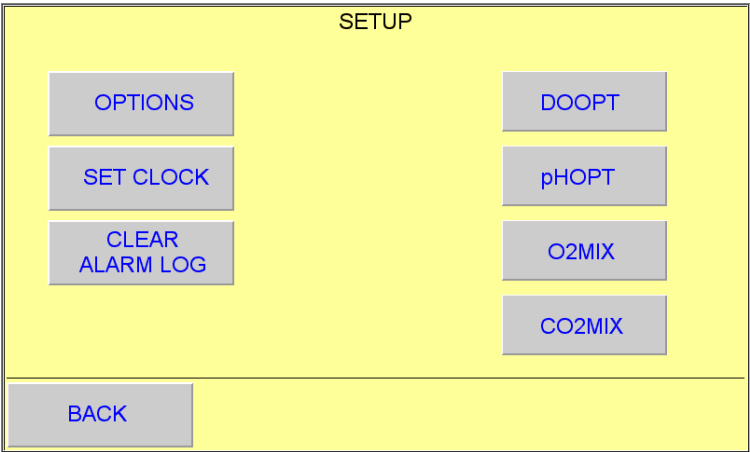
- | | |
|---|---|
| 1 | Connect the WAVEPOD II- WAVE Bioreactor interconnection cable to the port labeled WAVE 20/50 located on the rear panel of WAVEPOD II.
The illustration below shows WAVEPOD II rear panel to the left and WAVE Bioreactor base unit rear panel on the right: |
|---|---|



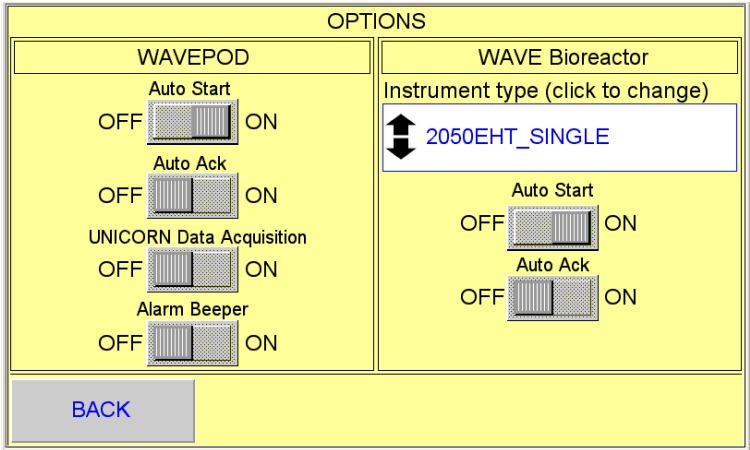
- | | |
|---|--|
| 2 | Connect the other end of the interconnection cable to the connector labeled DATAPORT 1 located on the rear panel of the WAVE Bioreactor instrument. |
| 3 | On the WAVEPOD II Touch screen, press SETUP in the MAIN MENU screen.
<i>Result:</i> the password screen opens. |



Step	Action
4	To enter the SETUP screen: • Press the password button **** and enter the password in the keypad that opens. The password is by default "2050". • Press PROCEED in the next screen. <i>Result:</i> the SETUP screen opens.



5	On the SETUP screen, press OPTIONS. <i>Result:</i> The OPTIONS screen is displayed.
---	--



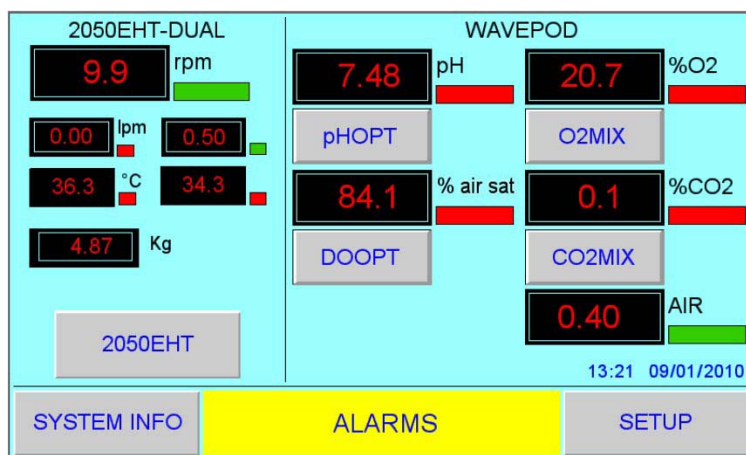
Step	Action
------	--------

- | | |
|---|---|
| 6 | <p>On the OPTIONS screen, select the type of WAVE Bioreactor instrument:</p> <ul style="list-style-type: none"> Press the arrows in the Instrument type field several times until the current instrument type is displayed Set UNICORN Data Acquisition to ON when UNICORN DAQ is connected Press BACK |
|---|---|

Note:

This is required to run in remote mode, see Communication during dual operation, on page 78.

- | | |
|---|--|
| 7 | <p>Switch off WAVEPOD II and then switch it on again to initiate communication with the connected bioreactor instrument.</p> <p>Result: After 20 seconds the SYSTEM INFO screen is displayed. Then the MAIN MENU screen with the data of the connected WAVE Bioreactor 20/50 instrument is displayed.</p> |
|---|--|



- | | |
|---|---|
| 8 | <p>If the communication fails, a Communication with WAVE Bioreactor failed message appears on the MAIN MENU screen.</p> <ul style="list-style-type: none"> Check that the cable between WAVEPOD II and WAVE Bioreactor 20/50 is properly connected. Check that the power is turned on to WAVE Bioreactor 20/50 <p>WAVEPOD II will automatically try to restart communication.</p> |
|---|---|

Communication during dual operation

One WAVEPOD II is required per Cellbag bioreactor. Thus, for dual operation two WAVEPOD II are needed for individual control of pH and/or DO. WAVE Bioreactor 20/50 is then controlled by WAVEPOD II connected to the left Cellbag bioreactor. WAVEPOD II connected to the right Cellbag bioreactor shall have **Instrument type** set to **NONE**.

Connect aeration

See Section 8.4 Connect aeration, on page 185.

Connecting acid/base pumps



WARNING
Disconnect power. Always disconnect power from the instrument before connecting the WAVE Bioreactor instrument or WAVEPOD II to any other instrument.

Two DB9 connectors for connection of PUMP20 acid and base pumps are located on the rear panel of WAVEPOD II. Connect the pumps as described in the table below if pH regulation with acid or base is required. Use the cables supplied with the pump modules.

Connect the...	to the connector marked...
acid pump	ACID PUMP
base pump	BASE PUMP

Connect acid/base solutions

See Section 8.3 Assembly of system, on page 179.

Connect to optional alarm monitor

WAVEPOD II provides an alarm log, described in *Section 6.4 Alarms, on page 151*. WAVEPOD II can also be connected to an external monitoring system to alert in the case of an alarm condition.

Connect the optional alarm to the dry contact **ALARM/ANALOG** on the rear panel. This contact will change state NO and NC if any alarm occurs or if power to WAVEPOD II is lost. Jack pinout is provided in the appendix.

4.5 Connecting to UNICORN DAQ 1.0

Introduction

This section provides an overview of the connection between UNICORN DAQ 1.0, WAVE Bioreactor 20/50 and optionally, WAVEPOD II.

Converter 100 must be connected between the computer running UNICORN DAQ 1.0 and WAVE Bioreactor. Data that is transferred to the **Primary** port on the Converter 100 is assigned **Left** in the UNICORN DAQ user interface, while that to the **Secondary** port is assigned **Right**.

For more information about...	read...
pinouts, IP addresses and networks	<i>Appendix C Communications and connections, on page 266</i>
connection between the computer and the converter	<i>Converter 100 Instructions</i>
install and set up UNICORN DAQ 1.0 for use with WAVE Bioreactor 20/50	<i>UNICORN DAQ 1.0 - User manual for WAVE Bioreactor</i>

Illustration of setup

The following image illustrates a connection between a WAVE Bioreactor instrument and a computer with UNICORN DAQ 1.0 installed.

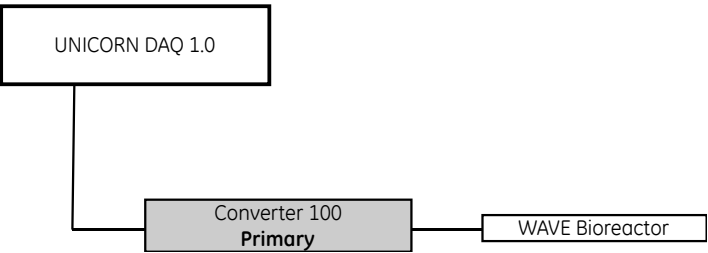
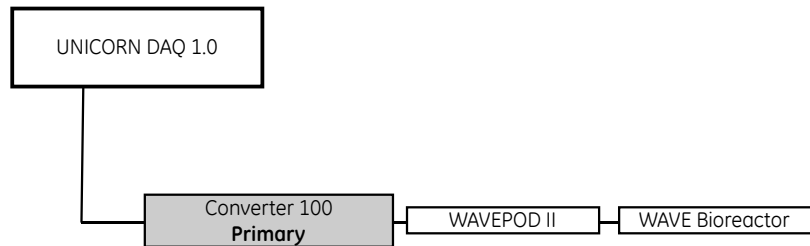


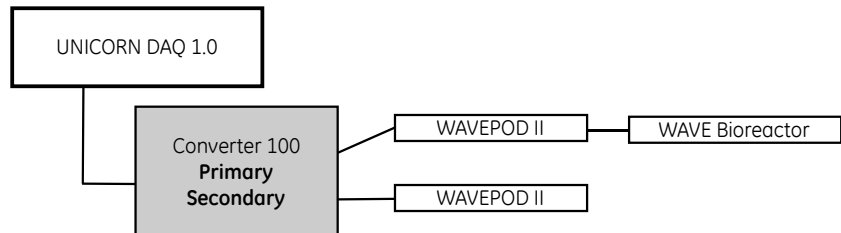
Illustration of setup with WAVEPOD II

The following image illustrates a connection between a WAVE Bioreactor instrument, WAVEPOD II and a computer with UNICORN DAQ 1.0 installed. When a WAVEPOD II controller is part of the system, UNICORN DAQ is connected to WAVEPOD II, not to the WAVE Bioreactor 20/50 instrument.

Single operation



Dual operation



One WAVEPOD II controller is required per Cellbag bioreactor. Thus, during dual operation, two WAVEPOD II controllers are used. However, the WAVE Bioreactor 20/50 instrument can only be connected with communication cable to one WAVEPOD II controller. One WAVEPOD II controller is operated in remote mode to control the instrument and one of the Cellbag bioreactors. The second WAVEPOD II controller is operated in local mode to control the second Cellbag bioreactor.

Connect instrument to converter

Connect the WAVE Bioreactor instrument to Converter 100.

If WAVEPOD II is used, the WAVE Bioreactor instrument should be connected to WAVEPOD II (see *Section 4.4 Installation of WAVEPOD II, on page 72*) and WAVEPOD II to the converter (see below).

Step	Action
1	Connect an RJ11 cable (part number 87001833) to the port labeled DATA-PORT 1 on the rear panel of the WAVE Bioreactor instrument.
2	Connect the other end of the cable to the port Primary on the rear panel of Converter 100.

Connect WAVEPOD II to converter

Connect the WAVEPOD II controller (controllers for dual operation) to Converter100.

Step	Action
1	Make sure that WAVEPOD II port WAVE 20/50 and WAVE Bioreactor 20/50 port DATAPORT 1 are connected properly, see <i>Section 4.4 Installation of WAVEPOD II, on page 72</i> .
2	Connect a RJ11 cable (part number 87001833) to the port CONVERTER on the rear panel of WAVEPOD II.
3	Connect the other end of the cable to the port Primary on the rear panel of the converter.
4	• For single operation, the connection is finished. • For dual operation, continue with the next step.
5	Connect a RJ11 cable (part number 87001833) to the port CONVERTER on the rear panel of the second WAVEPOD II controller. Note: <i>The second WAVEPOD II controller is not connected with communication cable to the WAVE Bioreactor instrument.</i>
6	Connect the other end of the cable to the connector Secondary on the rear panel of the converter.

Connect converter to the computer

For instructions about connecting the converter to the computer with UNICORN DAQ 1.0 installed, refer to *Converter 100 Instructions*.

5 WAVE Bioreactor control system

About this chapter

This chapter describes the embedded control systems in the WAVE Bioreactor instrument. The control system of the WAVEPOD II Controller is covered in *Chapter 6 WAVEPOD II Control system*, on page 115.

Note: *The control systems of the stand-alone instruments CO2MIX20, O2MIX20 and PUMP20 are not covered in this manual. Please see Stand-alone instruments for WAVE Bioreactor 2/10 and 20/50 Operating Instructions for further information.*

In this chapter

Section	See page
5.1 Main screen and general functions	84
5.2 Parameter controls	87
5.3 Alarms	102
5.4 Change operation settings	105

5.1 Main screen and general functions

Main screen

The WAVE Bioreactor 20/50 system is controlled by a Touch screen. The Touch screen is turned on when the WAVE Bioreactor 20/50 instrument is turned on. No login procedure is required and there are no different user levels. The available functions on the main screen of the Touch screen varies depending on the current system configuration. Three examples shown below:

- Dual option WAVE Bioreactor 20/50 system with one large Cellbag bioreactor.



- Dual option WAVE Bioreactor 20/50 system with two small Cellbag bioreactors.



- Single option WAVE Bioreactor 20/50 system with CO₂ control



The main screen displays two types of boxes, as described in the table below.

Box design	Function
Black box	Function button for parameter controls. Press to reach the corresponding detail screen.
Bordered box	Parameter value for the control to the left.

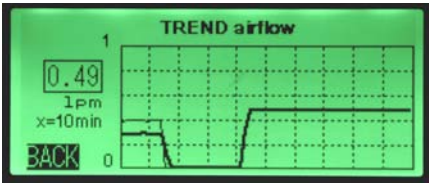
Part	Function
ROCKER	Rock speed control
rpm	Actual rocking speed
HEATER	Heating control
°C	Actual temperature of one or two Cellbags
WEIGHT	Weight of Cellbag bioreactor control
kg	Actual weight of Cellbag bioreactor(s)
AIR	Aeration control
lpm	Actual airflow of one or two Cellbag bioreactors
BAG	Cellbag bioreactor control
L/R ltr	Actual selected Cellbag bioreactor size(s) left (L) and right (R) in liter (ltr)
CO2 or O2	If optional settings: • CO₂ concentration control (CO2), or • O₂ concentration control (O2)
%CO2 or %O2	If optional settings: • Actual CO₂ concentration (%CO2) • Actual O₂ concentration (%O2)
ALARM	Alarm indicator
MENU	System setup and other functions

Note: The **ALARM** button will be displayed at the bottom of the screen only when alarm conditions exist. If the alarm is new and has not been acknowledged, then the **ALARM** button will be flashing.

Note: Each of the functions has a detailed screen which opens by pressing respective button.

General buttons

The buttons described below are available in most or all of different function detail screens.

Function	Description
TREND	Press the TREND button to get a graph for the parameter over a 10 minute period. One example is shown below. 
ALARM	See Section 5.3 Alarms, on page 102.
BACK	Press the BACK button to return from current screen to the main screen.

Note: *The Touch screen is equipped with an alarm history battery that has a lifetime of 10 years. A battery symbol with a line through it will appear in the lower right corner of the screen in the rare case that the battery is running low. If this is displayed, contact GE Healthcare service.*

5.2 Parameter controls

About this section

This section describes the parameter controls for the WAVE Bioreactor 20/50 instrument.

In this section

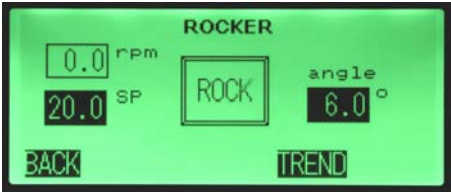
Section	See page
5.2.1 Rocking control	88
5.2.2 Weight control	89
5.2.3 Perfusion control	91
5.2.4 Cellbag and single/dual mode selection	93
5.2.5 Temperature control	94
5.2.6 Aeration control	96
5.2.7 CO ₂ concentration/aeration control	98
5.2.8 O ₂ concentration/aeration control	100

5.2.1 Rocking control

Introduction

The rocking is controlled through the **ROCKER** screen. Settings for both speed and angle are entered. Settings apart from set points are found through the SETUP screen, see *Section 5.4 Change operation settings, on page 105*.

Instruction

Step	Action
1	In the main screen press ROCKER (<i>Section 5.1 Main screen and general functions, on page 84</i>). <i>Result:</i> The ROCKER screen opens. Current rocking speed is shown in the <i>rpm</i> box. 
2	Set the rocking speed set point: • Press the SP box. • Enter desired set point (2 to 40 rpm) in the data entry keypad that opens • Press the ↵ key.
3	Set the rocking angle: • Press the angle box. • Enter desired set point (2 to 12 degrees) in the data entry keypad that opens. • Press the ↵ key.
4	Press ROCK to start rocking.
5	Check that the instrument rocks properly.
6	Press STOP (appears in the same position as ROCK) to stop rocking.

5.2.2 Weight control

Introduction

Weight control requires WAVE Bioreactor 20/50EHT-L instrument version. The weight is controlled through the **WEIGHT** screen. Settings for desired net weight are entered, and the feed and harvest pumps are controlled. Weight control is not available for Dual operation. Settings apart from set points are found through the SETUP screen, see *Section 5.4 Change operation settings, on page 105*.

Instruction

Step	Action
1	In the main screen press WEIGHT (<i>Section 5.1 Main screen and general functions, on page 84</i>). <i>Result:</i> The WEIGHT screen opens. The current net weight in kg is shown in the Kg net box.



2	Optional: To set net weight to zero: Press TARE. <i>Result:</i> The TARE NOW? screen opens.
---	--



- Press **TARE NOW** to set the net weight to zero. This cannot be undone. or,
- press **CANCEL** to return to the **WEIGHT** screen.

5 WAVE Bioreactor control system

5.2 Parameter controls

5.2.2 Weight control

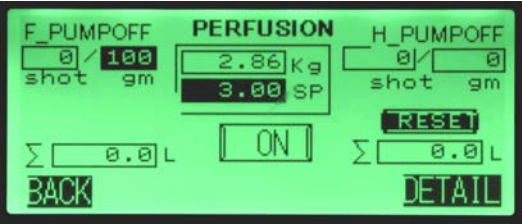
Step	Action
3	Set the net weight set point: • Press the SP box. • Enter desired set point (0.2 to 25 kg) in the data entry keypad that opens. • Press the ↵ key.
4	Start the feed pump by pressing the ON button below FEED. Note: <i>The FEED pump does not turn on if the net weight is higher than the high alarm limit.</i> <i>Result:</i> The button changes to OFF and the indicator Feeding appears. The feed pump runs until the net weight is above the setpoint.
5	Optional: To stop Feed control in advance press OFF to disable the FEED controller.
6	Start the harvest pump by pressing the ON button below HARV. Note: <i>The harvest pump (HARV) does not turn on if the net weight is less than the low alarm limit.</i> <i>Result:</i> The button changes to OFF and the indicator Harvesting appears. The harvest pump runs until the net weight is below the setpoint.
7	Optional: To stop Harvest control in advance press OFF to disable the HARV controller.

5.2.3 Perfusion control

Introduction

Perfusion control requires a WAVE Bioreactor instrument version with a loadcell integrated. The purpose of the Perfusion controller is to feed a set amount of medium to the Cellbag bioreactor over a 24 hour period (feed rate). The feed is divided into a number of shots. The equivalent amount of feed must be harvested. The Harvest controller keeps the weight constant (+/- deadband). The perfusion is controlled through the **PERFUSION** screen (only available in WAVE Bioreactor 20/50 EHT-L and EHTD-L instruments).

The perfusion screen overview



The left side of the screen shows the feed information:

- Current status of feed pump: **F_PUMPOFF** or **F_PUMPON** boxes.
- Amount feed added (**shot**)/to be added in this shot (**gm**).
- Cumulative feed (**L**): **Σ** box.

The right side of the screen shows the harvest information:

- Current status of harvest pump: **H_PUMPOFF** or **H_PUMPON** boxes.
- Amount harvest removed (**shot**) /to be removed (**gm**).
- Cumulative harvest (**L**): **Σ** box.

Instruction

Step	Action
1	In the main screen press PERFU (Section 5.1 Main screen and general functions, on page 84). Result: The PERFUSION screen opens.
2	Press RESET button to zero out both the feed and harvest cumulative amounts.

5 WAVE Bioreactor control system

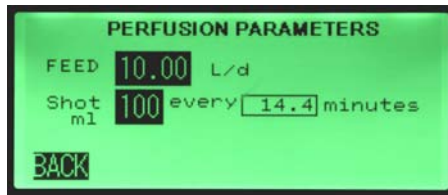
5.2 Parameter controls

5.2.3 Perfusion control

Step	Action
------	--------

3	Press DETAIL button.
---	-----------------------------

Result: The **PERFUSION PARAMETERS** screen opens.



4	Set the total feed by day (L/d):
---	---

- Press the **FEED** box.
- Enter desired set point in the data entry keypad that opens.
- Press the ↵ key.

5	Set the feed volume per shot:
---	-------------------------------

- Press the **Shot ml** box.
- Enter desired set point in the data entry keypad that opens.
- Press the ↵ key.

Result: The period in minutes between each shot is automatically calculated by values set for total feed by day and feed volume per shot.

6	Press BACK .
---	---------------------

7	Set the net weight set point:
---	-------------------------------

- Press the **SP** box.
- Enter desired set point (0.2 to 25 kg) in the data entry keypad that opens.
- Press the ↵ key.

8	Press ON to start the feed and harvest control.
---	--

Result: The feed pump starts and the harvest pump is activated when the weight exceeds the upper deadband limit and a full shot has been completed.

9	Press OFF to disable the perfusion controller, if desired.
---	---

5.2.4 Cellbag and single/dual mode selection

Introduction

The Cellbag bioreactor is selected through the **BAGSIZE** screen. Cellbag bioreactor bag size is entered.

Dual/Single mode selection is also made through the **BAGSIZE** screen. For Dual operation (not available unless WAVE Bioreactor 20/50 is designed for Dual use), it is possible to enter data for two Cellbag bioreactors if of small size. If a large Cellbag is selected only one bag can be used.

Instruction

Step	Action
1	In the main screen press BAG (Section 5.1 Main screen and general functions, on page 84).

Result: The **BAGSIZE** screen opens. The figure shows the setup screen for single operation to the left, and to the right for dual operation.



Note:

For Dual mode it is possible to select two Cellbag bioreactors if of small size. For Rocker tray 20 two bag sizes are available, 2 L and 10 L, and for Rocker tray 50 the 22 L bag is available. If one large sized Cellbag bioreactor is selected the information corresponding to the right Cellbag bioreactor is hidden.

2	Click Bag size to select the desired Cellbag bioreactor size. The bag size cycles through 2L-10L-20L-22L-50L for each press of the Bag size button. Click OK .
3	If necessary, repeat the selection for the second Cellbag bioreactor.
4	Click BACK to return to the Main screen.

5.2.5 Temperature control

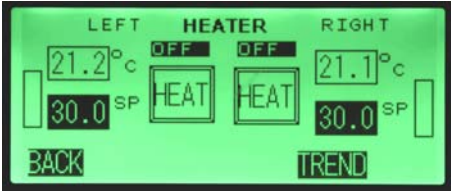
Introduction

The temperature is controlled through the **HEATER** screen. Settings for desired temperature are entered. Settings apart from set points are found through the SETUP screen, see *Section 5.4 Change operation settings, on page 105*. For Dual operation, each Cellbag bioreactor has its individual temperature control. Dual operation is possible if the instrument has Dual configuration and small Cellbag bioreactors are used. To select Cellbag bioreactor size, see *Section 5.2.4 Cellbag and single/dual mode selection, on page 93*.

Note: The temperature control system is automatically turned off if:

- Temperature sensor fails or is disconnected
- Heater is unplugged
- Heater overheats (> 60°C)
- Instrument is not rocking (this may be overridden in **SETUP**). The temperature control system resumes automatically when the rocking restarts.

Instruction

Step	Action
1	In the main screen press HEATER (<i>Section 5.1 Main screen and general functions, on page 84</i>). <i>Result:</i> The HEATER screen opens (the figure shows a Dual setup screen with two sets of commands, LEFT and RIGHT). Current Cellbag bioreactor temperature is shown in the box labeled °C. 
2	Note: <i>If one Cellbag bioreactor is used the Heater information is only shown for that Cellbag bioreactor and the information corresponding to the right Cellbag bioreactor is hidden.</i> If the incorrect setup (Dual/Single) is shown, follow the instruction in <i>Section 5.2.4 Cellbag and single/dual mode selection, on page 93</i> to change setup.

Step	Action
3	Set the temperature set point: • Press the SP box. • Enter desired set point (0°C to 45°C, no cooling available) in the data entry keypad that opens. Recommended minimum temperature is ambient temperature + 5°C, recommended maximum temperature is 40°C. • Press the ↵ key.
4	Press HEAT to start heating. Tip: The power output of the heater(s) is represented in the bar graph to the far left and far right of the screen
5	Press STOP (appears in the same position as HEAT) to stop heating.
Note:	<i>When operating the system with small liquid volumes, moderate over- and undershoots in temperature may occur when ramping liquid temperature to a new set-point significantly different from the actual temperature. Such behavior may also be seen when the new set point is close or closer to room temperature than the actual temperature as the system is not equipped with active cooling capabilities. These over- and undershoots intrinsic to the temperature control algorithm may occur within a period no longer than one hour after adjustment of the set-point. If over- or undershoots are considered undesirable for the application, the selection of an intermediate temperature set-point is recommended, for example 1 degree Celsius below or above the desired target temperature, respectively. After temperature stabilization at this intermediate set-point, the final set-point should be selected.</i>

5.2.6 Aeration control

Introduction

The aeration is controlled through the **AIRPUMP** screen. Settings for desired airflow are entered. Settings apart from set points are found through the SETUP screen, see *Section 5.4 Change operation settings, on page 105*. For Dual operation, each Cellbag bioreactor has its individual airpump control.



WARNING

Do not inflate the Cellbag bioreactor with any other device than the internal airpump. This has an automatic overpressure shutdown that will prevent overpressure. Direct connection to a gas source or use of any other pump may result in rupture of the Cellbag bioreactor.

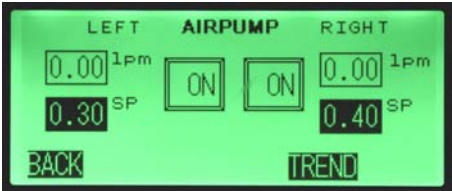


CAUTION

Pressure at the **Air In** port of WAVE Bioreactor must not exceed 0.1 bar. Exceeding this limit may cause rupture of the Cellbag bioreactor. Provide suitable safety pressure relief equipment.

Instruction

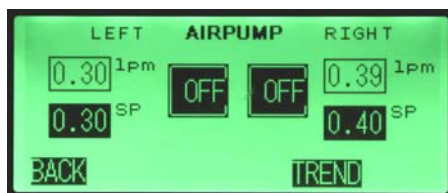
Step	Action
1	In the main screen press AIR (<i>Section 5.1 Main screen and general functions, on page 84</i>). <i>Result:</i> The AIRPUMP screen opens (the figure shows a Dual setup screen). Current airflow is shown in the lpm box.



Note:

If one Cellbag bioreactor is used, the Airpump information is only shown on the left side, and the information corresponding on the right side is hidden.

Step	Action
2	Set the aeration set point: • Press the desired SP box. • Enter desired set point (0 to 0.5 lpm) in the data entry keypad that opens. • Press the ↵ key.
3	If two bags are used, repeat the setting for the second Cellbag bioreactor.
4	Press ON (left and/or right in Dual setup) to start the air pump.
5	Press OFF (appears in the same position as ON) to stop the air pump.



5.2.7 CO₂ concentration/aeration control

Introduction

CO₂ concentration control by WAVE Bioreactor requires the WAVE Bioreactor 20/50EHT(-L)-CO₂ instrument configuration. The CO₂ concentration is controlled through the **CO₂ / AIRPUMP** screen. Settings for desired concentration are entered. Airflow is required for the CO₂ controller to function and the airflow controls are provided on the right side of the screen. Settings apart from set points are found through the SETUP screen, see *Section 5.4 Change operation settings, on page 105*.

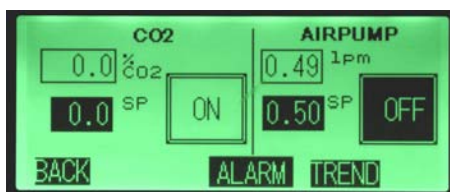
Note: CO₂ gas must be connected to the right side of the instrument. The pressure must be regulated to between 0.7 and 1.0 bar (10 and 15 psig).

Instruction

Note: CO₂ concentration control requires WAVE Bioreactor 20/50 EHT(-L)-CO₂ instrument configuration.

Tip: For information about controlling the airflow, see *Section 5.2.6 Aeration control, on page 96*.

Step	Action
1	In the main screen press CO₂ (<i>Section 5.1 Main screen and general functions, on page 84</i>). Result: The CO₂ / AIRPUMP screen opens. Current CO ₂ concentration is shown in the % CO₂ box.
2	If the airpump is not activated, set the airflow according to <i>Section 5.2.6 Aeration control, on page 96</i> . The controls on the right hand side of this screen (AIRPUMP) can be used.
3	Set the CO ₂ concentration set point: - Press the CO₂ SP box. - Enter desired set point (0% to 15%) in the data entry keypad that opens. - Press the ↵ key.



- If the airpump is not activated, set the airflow according to *Section 5.2.6 Aeration control, on page 96*. The controls on the right hand side of this screen (**AIRPUMP**) can be used.
- Set the CO₂ concentration set point:
 - Press the **CO₂ SP** box.
 - Enter desired set point (0% to 15%) in the data entry keypad that opens.
 - Press the ↵ key.

Step	Action
4	Press ON to start the airpump, if it is off. Press ON to start the CO ₂ control.
5	Press STOP (appears in the same position as ON) to stop the air pump.

5.2.8 O₂ concentration/aeration control

Introduction

O₂ concentration control requires WAVE Bioreactor 20/50EHT(-L)-O₂ instrument configuration. The O₂ concentration is controlled through the **O₂ / AIRPUMP** screen. Settings for desired concentration are entered. Airflow is required for the O₂ controller to function and the airflow controls are provided on the right side of the screen. Settings apart from set points are found through the SETUP screen, see *Section 5.4 Change operation settings, on page 105*.

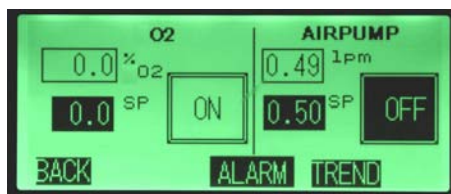
Note: O₂ gas must be connected to the right side of the instrument. The pressure must be regulated to between 0.7 and 1.0 bar (10 and 15 psig).

Instruction

Note: O₂ concentration control requires WAVE Bioreactor 20/50EHT(-L)-O₂ instrument configuration.

Tip: For information about controlling the airflow, see *Section 5.2.6 Aeration control, on page 96*.

Step	Action
1	In the main screen press O₂ (<i>Section 5.1 Main screen and general functions, on page 84</i>). <i>Result:</i> The O₂ / AIRPUMP screen opens. Current O ₂ concentration is shown in the % O₂ box.
2	If the airpump is not activated, set the airflow according to <i>Section 5.2.6 Aeration control, on page 96</i> . The controls on the right hand side of this screen (AIRPUMP) can be used.
3	Set the O ₂ concentration set point: - Press the O₂ SP box. - Enter desired set point (21% to 50%) in the data entry keypad that opens. - Press the ↵ key.



2 If the airpump is not activated, set the airflow according to *Section 5.2.6 Aeration control, on page 96*. The controls on the right hand side of this screen (**AIRPUMP**) can be used.

3 Set the O₂ concentration set point:

- Press the **O₂ SP** box.
- Enter desired set point (21% to 50%) in the data entry keypad that opens.
- Press the ↵ key.

Step	Action
4	Press ON to start the air pump, if it is off. Press ON to start the O ₂ control.
5	Press STOP (appears in the same position as ON) to stop the air pump.

5.3 Alarms

Introduction

The alarms are handled in the **ALARMS** screen.

The alarm history is stored in the Touch screen. The alarm history is retained on power failure or shutdown. The last 1000 alarms are retained. If the Touch screen is interchanged between WAVE Bioreactor instruments, the alarm history is lost.

Note: *Normally the user must acknowledge any new alarm by pressing the **ALARM** button to view the alarm history screen. If the **AUTOACK** feature is set to **ON** on the **SETUP:OPTIONS** screen then all alarms are automatically acknowledged. No warnings are generated but the alarm is still logged.*

Alarm indication

A new alarm is indicated by:

- A flashing **ALARM** button appears on the bottom of the displayed screen.
- The screen background color changes to red. This indicates that the alarm has not been acknowledged.
- An audible beeper sounds. The beeper can be turned off via the **SETUP** screen, see *Setting other options, on page 113*.

Once the **ALARMS** screen has been opened, the alarm is acknowledged. The main screen background returns to the color green and the **ALARM** button at the bottom of the main screen stops flashing, but it remains visible as long as any alarm condition exists.

Alarm screen information

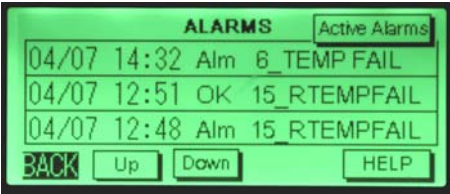
On the **ALARMS** screen each alarm is recorded. Each alarm message has:

- The date and time the alarm occurred or when it was cleared.
 - Alarm status (**Alm** = not cleared, **OK** = cleared).
 - The alarm code number, and short description, see *Alarm messages, on page 242*.
-

To handle an alarm

All alarms have a specified code and are time-stamped to facilitate troubleshooting (see *Alarm messages, on page 242*).

Step	Action
1	In the main screen (see <i>Section 5.1 Main screen and general functions, on page 84</i>), press the ALARM button. <i>Result:</i> The ALARMS screen opens. This action also acknowledges the alarm.



2	Press Up or Down buttons to scroll through the alarm history list.
3	To access a help screen for alarms: • Press desired alarm to highlight it. • Press HELP.
4	To get a list of currently active alarms, press the Active Alarms button.



5	Check the alarm (for alarm code, see <i>Alarm messages, on page 242</i>) and solve the alarm issue.
---	--

To view alarm history

To view the alarm history and active alarm list:

- Press the **ALARM** button in the main screen (if visible) or
- Press **MENU** in the main screen and then **ALARM** in the **MENU** screen.

External alarms

A unit alarm is provided by a DB15 female jack on the instrument back for optional alarm chart recorders and remote monitoring, see *Section C.2 Analog/alarm port, on page 269*. If any alarm condition exists, this triggers the **UNIT ALARM**. This activates the alarm contacts. The **UNIT ALARM** is set to **OFF** only if no alarm conditions are present.

5.4 Change operation settings

Introduction

Settings apart from set points are found through the SETUP screen. These include, for example, enable/disable alarms and sample position. All selections are retained in non-volatile memory and are preserved on power off.

Enter the settings screen

Step	Action
1	In the main screen press MENU. (Section 5.1 Main screen and general functions, on page 84) Result: The MENU screen opens. The MENU screen shows system information.



2	Press SETUP button. Result: The Access SETUP screen opens.
---	--



Step	Action
3	- Click on Enter Password box - Enter password 2050 - Press ↵ key. Result: The SETUP screen opens.



Note: The list of displayed setup buttons depends on the configuration of the instrument.

Setting rocker options

Press the **ROCKER** button. The **ROCK SETUP** screen appears.

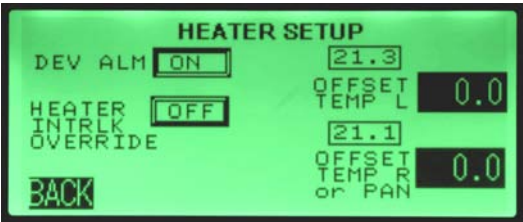


Part	Function
DEV ALM	This setting enables or disables the speed deviation alarm monitor. The default setting is ON, which activates an alarm if the measured speed differs from the set point by more than 2 rpm. Press the box to toggle between enabled (ON) and disabled (OFF).

Part	Function
SAMP POS	This setting determines the tilt angle, in degrees, that the machine moves to when the rocking is stopped. The default value is 12. Press the box to bring up a keypad, where a new value between 0 and 12 degrees can be entered. The machine moves to the new position immediately.
ACC	This setting is currently not used.
ROCK MODE	This setting determines if the rocking occurs continuously or in cyclic periods. The default value is CONT, which corresponds to continuous rocking. Press the box next to ROCK MODE to toggle between continuous mode (CONT) and cyclic mode (CYCLE). In the CYCLE mode, set the desired on and off times from 1 to 9,999 seconds.
BACK	Press this box to return to the SETUP screen.

Setting heater options

Press the **HEATER** button. The **HEATER SETUP** screen appears.



Part	Function
DEV ALM	This setting enables or disables the temperature deviation alarm monitor. By default, this setting is enabled (ON). When the setting is enabled and the measured temperature is within 0.5°C from the set point, monitoring of temperature deviation starts. If the temperature then differs from the set point by more than 1°C during 1 minute, the alarm is activated.

Part	Function
HEATER INTRLK OVERRIDE	This setting enables or disables the heater when the rocker is stopped. By default, the heater is disabled (OFF). Normally, it is not desired to heat when the rocker is stopped as this may cause local hot spots. However, this interlock can be disabled by setting the option to ON.
OFFSET TEMP L	This setting can be used to compensate for temperature probe calibration. The default value is set at the factory and is specific to the probes delivered with the instrument. The range is -10.0°C to +10.0°C. In instruments with dual option, this setting affects the temperature sensor on the left side.
OFFSET TEMP R	This setting is similar to OFFSET TEMP L, but is only available if the instrument is equipped with the DUAL option. In such instruments, this setting determines the offset for the temperature sensor on the right side.
BACK	Press this box to return to the SETUP screen.

Setting aeration options

Press the **AIR** button. The aeration setup screen appears.



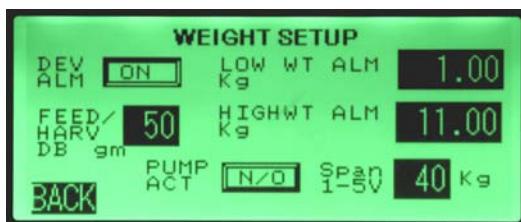
Part	Function
DEV ALM	This setting enables or disables the airflow deviation alarm monitor. By default, the monitor is enabled (ON), which activates an alarm if the measured airflow differs from the set point by more than 0.1 lpm. Press this box to enable (ON) or disable (OFF) the monitor.
L AIR SPAN	This setting is a scale factor, used by qualified technicians to calibrate the flow rate of the left air pump. The default value is 1000 mL/min.

Part	Function
R AIR SPAN	This setting is a scale factor, used by qualified technicians to calibrate the flow rate of the right air pump. The default value is 1000 mL/min.
BACK	Press this box to return to the SETUP screen.

Setting weight options

Note: Weight options are only useful if an LCELL2050EHT has been installed and enabled in the **SETUP OPTIONS** screen.

Press the **WEIGHT** button. The **WEIGHT SETUP** screen appears.



Part	Function
DEV ALM	This setting enables or disables the weight deviation alarm monitor. When the setting is ON , an alarm is activated when the measured weight differs from the set point by more than 4 times the feed shot volume.
FEED/HARV DB	This setting determines the deadband around the weight set-point. The weight is maintained within the deadband. A small deadband causes the feed and harvest pumps to engage more often. A large deadband decreases the weight control accuracy. The range is 50 to 500 g. The default value is 50 g.
LOW WT ALM LIMIT	Determines the lower threshold value for the weight alarm. The range is 0 to 40.00 kg. The default value is 1.00 kg.
HIGH WT ALM LIMIT	Determines the upper threshold value for the weight alarm. The range is 0 to 50.00 kg. The default value is 11.00 kg.
PUMP ACT	N/C means that the contact closes when actuated. N/O means that the contact opens when actuated.

Part	Function
SPAN	Note: <i>This value is set at the factory and must not be changed.</i> This setting indicates the operating voltage of the load cell and ranges from 1 to 5 V. 40 represents the capacity in kg.
BACK	Press this box to return to the SETUP screen.

Setting CO₂ controller options

Note: CO₂ controller options are only available if the WAVE Bioreactor instrument has a CO₂ control module.

Press the **CO2** button. The **CO2 SETUP** screen appears.

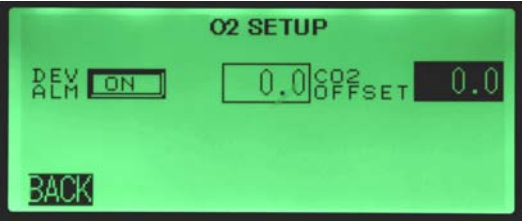


Part	Function
DEV ALM	This setting enables or disables the CO ₂ deviation alarm monitor. By default, the monitor is enabled (ON), which activates an alarm if the measured CO ₂ concentration differs from the set point by more than 1% CO ₂ . Press this box to enable (ON) or disable (OFF) the monitor.
CO2 OFFSET	This setting can be set to compensate for CO ₂ sensor calibration. The range is -10% to +10%. The default value is set at the factory for the sensors delivered with the instrument.
BACK	Press this box to return to the SETUP screen.

Setting O₂ controller options

Note: O₂ controller options are only available if the WAVE Bioreactor instrument has an O₂ control module.

Press the **O2** button. The **O2 SETUP** screen appears.



Part	Function
DEV ALM	This setting enables or disables the O ₂ deviation alarm monitor. By default, the monitor is enabled (ON), which activates an alarm if the measured O ₂ concentration differs from the set point by more than 1% O ₂ . Press this box to enable (ON) or disable (OFF) the monitor.
O2 OFFSET	This setting can be set to compensate for O ₂ sensor calibration. The range is -10% to +10%. The default value is set at the factory for the sensors delivered with the instrument.
BACK	Press this box to return to the SETUP screen.

Setting the real-time clock

Press the **SETCLK** button. The **SET CLOCK** screen appears.



For setup instructions, see *Setting the clock, on page 69*.

Setting analog options

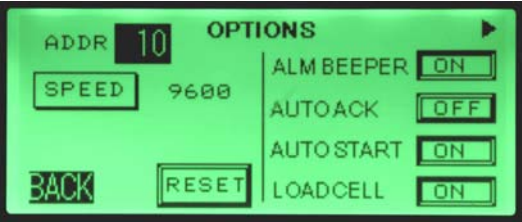
Press the **ANALOG** button. The **ANALOG OUTPUT** screen appears.



Part	Function
ANALOG	This setting enables (ON) or disables (OFF) analog outputs on the DB15 connector located on the rear of the instrument. These signals can be used to record data and interface to analog data acquisition/alarm systems. The default setting is OFF .
OUTPUT	This setting determines if the voltage of the analog output is in the range of 0 to 5 V or 1 to 5 V. The default is 1 to 5 V. The 1 to 5 V choice is safer, because any voltage below 1 volt-age will signal the acquisition/alarm system that the instrument has either lost power or the analog output module has failed.
CH1 through CH6	The signal for each analog output channel can be assigned by the user. Each channel may be set to the following parameters: • NONE • SPEED • NET WT • TEMPL • AIRL • TEMPR • AIRR • CO2 • O2 The pin assignments and default values for each channel are shown in <i>Section C.2 Analog/alarm port, on page 269</i>.

Setting other options

Press the **OPTIONS** button. The **OPTIONS** screen appears.



Part	Function
arrow	Scroll to see more options.
ALM BEEPER	This setting enables (ON) or disables (OFF) the alarm beeper. The default is ON .
AUTO ACK	Set this option to ON to automatically acknowledge any new alarm. The default value is OFF (disabled).
AUTO START	When this setting is enabled (ON), the instrument starts in the same state as at the time of the last shutdown. The default value is ON .
LOADCELL	This setting enables (ON) or disables (OFF) the weight sensor. The default value is OFF , unless the required option LCELL20/50EHT was installed at the factory.
ADDR	The current MODBUS address of the instrument. The default address is 10. Note: Press RESET to apply any changes.
SPEED	The current speed (in baud) of the MODBUS port. The available values are 9600 (default), 19.2K or 38.4K.  CAUTION Do not change this setting.

Note: Press **RESET** to apply any changes.

Selection of dual and single operation mode

Dual system instruments (WAVE Bioreactor 20/50EHTD) can be used for both dual and single operation. For small bag sizes both **SINGLE** and **DUAL** modes are available, for large bags only **SINGLE** mode is available. By selecting bags **SINGLE** and **DUAL** mode is set, see *Section 5.2.4 Cellbag and single/dual mode selection, on page 93*.

SINGLE mode

- The instrument behaves like an EHT with left side temperature and airflow controls only.
- The right side heater can be switched off, or set to operate in parallel with the left side heater.

DUAL mode

The temperature and airflow are controlled independently for the left and right sides.

6 WAVEPOD II Control system

About this chapter

The optional external instrument WAVEPOD II combines a number of instrument modules for use with WAVE Bioreactor 20/50 system. It can provide dissolved oxygen measurement and control, pH measurement and control, aeration control and O₂ and/or CO₂ gas mixing. This chapter describes the software that controls WAVEPOD II.

In this chapter

Section	See page
6.1 WAVEPOD II main screen and general functions	116
6.2 System information screen	119
6.3 WAVEPOD II Parameter controls	120
6.4 Alarms	151
6.5 Change operation settings	154

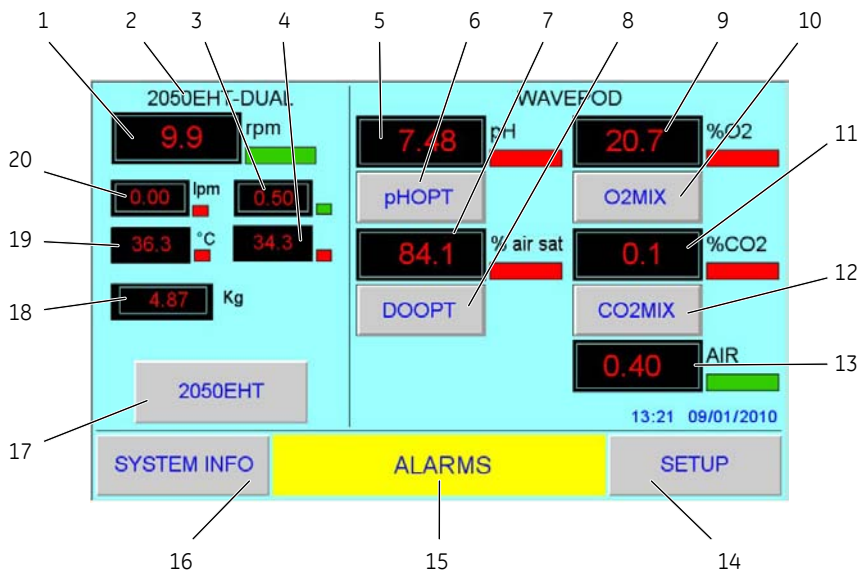
6.1 WAVEPOD II main screen and general functions

WAVEPOD II main screen

WAVEPOD II is controlled via a Touch screen. The available functions on the main screen of the Touch screen varies depending on the current configuration.

A description of the user interface in the main screen is presented in the table below, followed by an illustration of the main screen.

Type/location	Function
Left side of the screen	Data from the WAVE Bioreactor instrument connected to WAVEPOD II, if the instrument is operating in remote control mode
Right side of the screen	Data from WAVEPOD II
Red numerals in black box	Measured process variables
Grey box	Function button. The detail screen is reached by pressing the respective button.
Green bar	Corresponding control function is on
Red bar	Corresponding control function is off



Part	Description	Part	Description
1	Actual rocking speed (<i>rpm</i>)	11	Measured CO ₂ (%CO2)
2	Connected WAVE Bioreactor	12	CO2MIX button for control of CO ₂ concentration
3	Actual aeration value of WAVE Bioreactor (<i>lpm</i>) for the right bag when using dual mode.	13	Measured aeration value for WAVEPOD II.
4	Actual temperature value (°C) for the right bag when using dual mode.	14	SETUP button for operation settings
5	Measured pH	15	ALARMS button for alarm handling
6	pHOPT button for pH control	16	SYSTEM INFO button for system information
7	Measured dissolved oxygen (% air sat)	17	Connected WAVE Bioreactor (2050EHT) button
8	DOOPT button for control of dissolved oxygen	18	Loadcell option only: Actual net weight value (kg)
9	Measured O ₂ (%O2)	19	Actual temperature value (°C)
10	O2MIX button for control of O ₂ concentration	20	Actual aeration value of WAVE Bioreactor (lpm)

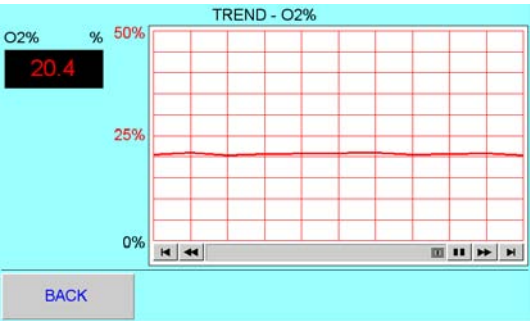
General buttons

Functions available in most or all of the different detail screens:

Function	Description
BACK	Press the BACK button to return to the previous screen.
ALARMS	Press the ALARMS button to view the alarm log and acknowledge alarms. See <i>Section 6.4 Alarms, on page 151</i> .
TREND	Press the TREND button to view a trend graph for the parameter.

Trend

Values for each parameter are saved over a 10 hour period, and can be viewed by pressing the **TREND** button in parameter control screens. WAVEPOD II does not maintain long-term trends. A typical TREND screen is shown below. The table below describes the functions of the buttons under the graph.



Part	Function
I<	View initial interval of measurement
<<	Go back in time (one square at a time)
II / I>	Pause /restart current view
>>	Go forward in time (one square at a time)
>I	View last interval of measurement

6.2 System information screen

Introduction

The **SYSTEM INFORMATION** screen provides information about the system, including alarms and communications with WAVE Bioreactor 20/50. The screen is reached by pressing **SYSTEM INFORMATION** in the **MAIN MENU** screen of WAVEPOD II.

System information screen



The **SYSTEM INFORMATION** screen on WAVEPOD II provides:

- System configuration information
- **ALARM STATUS** box: Alarms concerning WAVE Bioreactor. Green circles indicate no alarms and red circles indicate alarms.
- **COMMUNICATION STATUS** box: Communication with WAVE Bioreactor and, optionally, UNICORN DAQ software. Green circles indicate working communication and red circles indicate no working communication.
- **ALARMS** button for information about individual alarms
- **BACK** button.

Tip: Alarms are further described in Section 6.4 Alarms, on page 151.

6.3 WAVEPOD II Parameter controls

About this section

This section describes the parameter controls for the WAVEPOD II instrument.

In this section

Section	See page
6.3.1 pH control	121
6.3.2 Dissolved oxygen control	130
6.3.3 Aeration control	139
6.3.4 O ₂ concentration control	140
6.3.5 CO ₂ concentration control	143
6.3.6 WAVE Bioreactor instrument remote control	146

6.3.1 pH control

Introduction

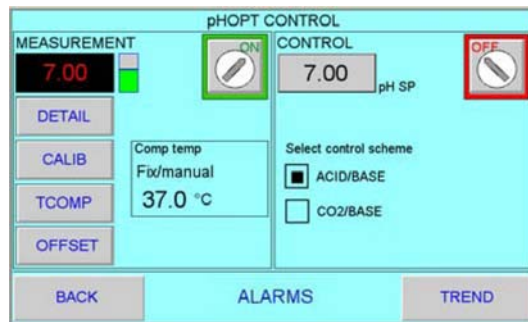
The pH is controlled through the **pHOPT CONTROL** screen.

For further information about pH measurement and control, please read *Section B.2 pH measurement and control, on page 257*.

Note: When UNICORN DAQ is used, make sure that the **pH WAVEPOD** configuration is selected to log pH readings (**UNICORN Manager: System Setup: Components**). For trouble shooting purpose it is strongly recommended to also select **pH Details** to log LED, amplitude and phase angle.

pHOPT CONTROL screen

Basic layout



The left hand side of the **pHOPT CONTROL** screen provides measurement data:

- Actual pH display box
- pHOPT sensor bar graph showing signal amplitude
- pH measurement button (**ON/OFF**)
- **DETAIL** button for sensor information
- **CALIB** button for sensor parameters settings
- **TCOMP** button for temperature compensation
- **OFFSET** button for offset calibration

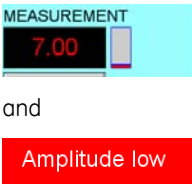
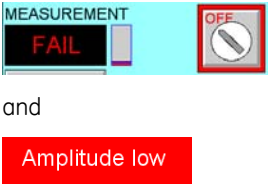
The right hand side of the **pHOPT CONTROL** screen provides control data:

- Setpoint pH (**pH SP**) display box

- pH control button (**ON/OFF**)
Note: The pH control requires that pH measurement is active.
 - **ACID/BASE** or **CO2/BASE** control scheme selection
- The bottom of the **pHOPT CONTROL** screen provides:
- **BACK**, **ALARMS** and **TREND** buttons

pHOPT sensor condition

Note: The values in the table below are examples only.

If the pHOPT screen displays...	then...	Action
	the pHOPT sensor functions correctly.	
	the signal from the pHOPT sensor is low. This may reduce the accuracy of the pH measurement.	• Check that the optical fibre is properly connected at both ends. • A 90° rotation of the bag adaptor may improve the signal. • Exchange the optical fiber.
	the signal from the pHOPT sensor is too low to obtain pH reading.	Perform the following actions in order until the problem is solved: • Check the attachment of the optical fiber at both ends • Replace the optical fiber • Replace Cellbag • Contact GE Healthcare service

During pH control

When pH control is started, additional information is provided.

For CO2/BASE control scheme:

- Cycle time (time left and total cycle time)

- Base pump activity, as set by pH controller
- CO₂ set point, as set by pH controller
- CO₂ ON/OFF (green bar when on, red bar when off)
- AIR ON/OFF (green bar when on, red bar when off)

For ACID/BASE control scheme:

- Cycle time (time left and total cycle time)
- Base pump activity, as determined by pH controller
The amount of added acid or base is controlled by turning the pump on (at a fixed rate) for a certain percentage of the time in each control cycle.
- Acid pump activity, as determined by pH controller
The amount of added acid or base is controlled by turning the pump on (at a fixed rate) for a certain percentage of the time in each control cycle.
- Addition time per cycle (seconds, acid or base)

Control schemes

The following control schemes are available for pHOPT control.

Scheme	Control option
Acid/Base	pH control by addition of acid and base. At pH below the selected pH setpoint, base is added. At pH above the selected pH setpoint, acid is added.
CO ₂ /Base	pH control by change of CO ₂ concentration in the gas to the headspace and by base addition. At pH below the selected pH setpoint, an attempt is first made to reach the requested pH value by lowering the CO ₂ level. If requested pH level is not reached within the selected CO ₂ -> Base delay time, base is added. At pH above the selected pH setpoint, the CO ₂ concentration is increased.

Note: The CO₂/Base control scheme requires that carbondioxide supply is connected to a CO₂MIX control module.

Temperature compensation

The following selections are available for temperature compensation for DOOPT II and pHOPT:

Selection	Alternatives	Comment
Compensation mode	- Manual - Automatic	In manual mode, the temperature of the measured solution is entered manually. In automatic mode, the temperature is read from temperature sensor at the bag tray of the BASE 20/50. During dual operation the automatic mode will read the temperature from one temperature sensor only. If pH/DO control is required for the other side, a second WAVEPOD II controller must be used, together with manual temperature compensation.
Cellbag position	- Single / Left - Right	For single operation, select single. For dual operation, select left or right depending on the bag to be measured.
Temperature compensation value	- Enter manual value - Leave as is	During manual mode, this value is used. During automatic mode, the measured value is used instead.

Select automatic or manual temperature compensation	
Manual Tcomp	Auto Tcomp
Select left or right if you have a dual WAVE Bioreactor, otherwise select single	
Single or left	Right
Select value for manual temperature compensation	
25.0 °C	
BACK	

Note: During dual operation, one WAVEPOD II controller is used per Cellbag bioreactor. The WAVEPOD II controller that is used in remote mode, connected to WAVE Bioreactor, can use either automatic or manual temperature compensation. The WAVEPOD II controller that is used in local mode must use manual temperature compensation. During dual operation the automatic compensation mode will read the temperature from the left side temperature sensor only. If DO and/or pH control is required also at the right side a second WAVEPOD II controller has to be used, together with manual temperature compensation.

pHOPT calibration

Step	Action
1	Press the pHOPT button in the MAIN MENU screen (Section 6.1 WAVEPOD II main screen and general functions, on page 116). Result: The pHOPT screen opens.

Step	Action
2	Enter the pH sensor parameters: Press CALIB button. Result: the pH SENSOR PARAMETERS screen opens.

pH SENSOR PARAMETERS

cmin	0.00	cmax	0.00
cpH0	0.00	cdpH	0.00
ctemp	0	SET	

BACK

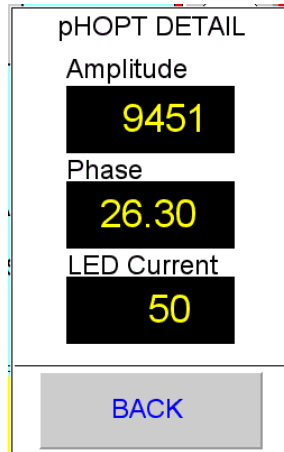
- Enter the five calibration values listed on the Cellbag label.
- Press **SET**.

Step	Action
------	--------

3	View signal information, if desired:
---	--------------------------------------

- Press **DETAIL** to verify the signal quality.

Result: A pop-up window displays sensor parameters: amplitude, phase of the signal and LED current.



Note:

If the amplitude is outside the recommended measurement range (5000-10000), the LED current will automatically be adjusted and the amplitude will soon return to the recommended measurement range.

Note:

Initially, the LED will have a high starting value (160). During the next few minutes it will be regulated to its operating level.

4	Press ON/OFF button to the left to start pH measurement.
---	---

Result: The button changes to green and displays **ON**.

Note:

If the media in the bag has not yet reached a temperature of approximately room temperature, the pH measurement value may not be visible in the display. The pHOPT sensor should be soaked in the media at least one hour before it can be expected to give a good measurement.

Step	Action
5	Change pH setpoint value: - Click the SP display box - Enter a new setpoint (pH range 6 to 8) in the data entry keypad that opens. - Press the ENT key to accept the new setpoint, CLR to clear the display or ESC to abort data entry.
6	Select control scheme by pressing the box beside the desired mode: ACID/BASE CO2/BASE
7	Set temperature compensation: Press the TCOMP button. <i>Result:</i> A temperature compensation screen opens.

Select automatic or manual temperature compensation

Manual
Tcomp

☒

Auto
Tcomp

Select left or right if you have a dual WAVE Bioreactor,
otherwise select single

Single
or left

☒

Right

Select value for manual temperature compensation

37.0

°C

BACK

- Select manual (**Manual temp**) or automatic (**Auto temp**) temperature compensation.
- Select bag position: **Single or left** or **Right**
- If manual temperature compensation is selected, continue with next step. Otherwise, press **BACK** and continue with starting the pH control.

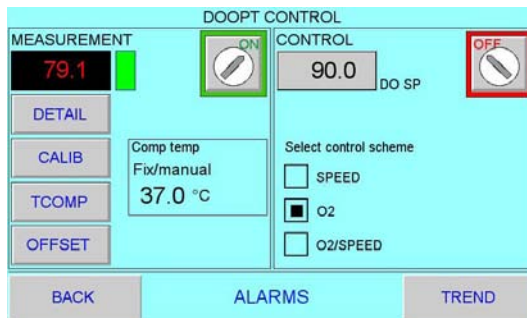
Step	Action
8	Set manual temperature value: - Press the temperature button in the temperature compensation screen. - Enter a new value in the data entry keypad that opens. - Press the ENT key to accept the new value, CLR to clear the display and ESC to abort data entry. Press BACK to return to the pHOPT control screen.
9	Press ON/OFF button to the right to start pH control. <i>Result:</i> The button changes to green and displays ON. Information about the control is displayed on the screen. Note: <i>pH control should not be started until the temperature is stable and as desired, and the pH measurement shows a stable and reliable value.</i>
10	Offset calibration of the pH sensor: - Press OFFSET. <i>Result:</i> The OFFSET CALIBRATION screen opens. - Enter the measured value and press SET. For details, see <i>Offset pHOPT calibration, on page 208</i>. - Press BACK when calibration is done.
11	When desired, press ON/OFF button to the right to stop pH control. <i>Result:</i> The button changes to red and displays OFF.
12	When desired, press ON/OFF button to the left to stop pH measurement. <i>Result:</i> The button changes to red and displays OFF.

6.3.2 Dissolved oxygen control

Introduction

The dissolved oxygen (DO) is controlled through the **DOOPT CONTROL** screen.

DOOPT CONTROL screen



The left hand side of the **DOOPT** screen provides measurement data:

- Actual DO display box
- DOOPT sensor bar graph showing signal amplitude
- DO measurement button (**ON/OFF**)
- **DETAIL** button for sensor information
- **CALIB** button for sensor parameters setting
- **TCOMP** button for temperature compensation
- **OFFSET** button for offset calibration
- **Comp temp** temperature display box

The right hand side of the **DOOPT** screen provides control data:

- Setpoint DO (**DO SP**) display box
- DO control button (**ON/OFF**)
- **Note:** The DO control requires that DO measurement is active.
- **SPEED** or **O2** or **O2/SPEED** control scheme selection

The bottom of the **DOOPT** screen provides:

- **BACK**, **ALARMS** and **TREND** buttons

DOOPT II sensor condition

If the DOOPT screen displays...	then...	Action
	the DOOPT II sensor functions correctly	
 and 	the signal from the DOOPT II sensor is low. This may reduce the accuracy of the DO measurement. The reason may be a degraded sensor or signal loss due to bad fiber cable or connection.	Check that the optical fibre is properly connected at both ends. A 90° rotation of the bag adaptor may improve the signal. Exchange the optical fiber.
 and 	the signal from the DOOPT II sensor is too low to obtain a DO reading.	Perform the following actions in order until the problem is solved: • Check the attachment of the optical fiber at both ends • Replace the optical fiber • Replace Cellbag • Contact GE Healthcare service

During DO control

When DO control is started, additional information is provided:

- Cycle time (time left and total cycle time)
- O2 set point, as set by DO controller
- O2 ON/OFF (green bar when on, red bar when off)
- AIR ON/OFF (green bar when on, red bar when off)

Control schemes

Mode	Control option
Speed	Dissolved oxygen control by change of the rocking rate. At low DO the rocking rate is increased, and at high DO the rocking rate is decreased.
O2 concentration	Dissolved oxygen control by change of O ₂ concentration in the gas to the headspace. At too low DO the O ₂ concentration is increased, and at too high DO the O ₂ concentration is decreased.
Speed/ O2 concentra- tion	Dissolved oxygen control by change of O ₂ concentration and of the rocking rate up to a set value (user defined). When DO is too low, O ₂ concentration is increased first. If the O ₂ concentration increase is not sufficient, the rocking rate will be increased.

Note: The O₂% mode requires that oxygen supply is connected to a O2MIX control module on WAVEPOD II and that the airpump is turned on.

Temperature compensation

The following selections are available for temperature compensation for DOOPT II and pHOPT:

Selection	Alternatives	Comment
Compensation mode	- Manual - Automatic	In manual mode, the temperature of the measured solution is entered manually. In automatic mode, the temperature is read from temperature sensor at the bag tray of the BASE 20/50. During dual operation the automatic mode will read the temperature from one temperature sensor only. If pH/DO control is required for the other side, a second WAVEPOD II controller must be used, together with manual temperature compensation.

Selection	Alternatives	Comment
Cellbag position	- Single / Left - Right	For single operation, select single. For dual operation, select left or right depending on the bag to be measured.
Temperature compensation value	- Enter manual value - Leave as is	During manual mode, this value is used. During automatic mode, the measured value is used instead.

Select automatic or manual temperature compensation

Manual Tcomp

Auto Tcomp

Select left or right if you have a dual WAVE Bioreactor, otherwise select single

Single or left

Right

Select value for manual temperature compensation

25.0

°C

BACK

Note: During dual operation, one WAVEPOD II controller is used per Cellbag bioreactor. The WAVEPOD II controller that is used in remote mode, connected to WAVE Bioreactor, can use either automatic or manual temperature compensation. The WAVEPOD II controller that is used in local mode must use manual temperature compensation. During dual operation the automatic compensation mode will read the temperature from the left side temperature sensor only. If DO and/or pH control is required also at the right side a second WAVEPOD II controller has to be used, together with manual temperature compensation.

DOOPT calibration

Step	Action
1	Press the DOOPT button in the main screen (Section 6.1 WAVEPOD II main screen and general functions, on page 116). Result: The DOOPT screen opens.
2	Enter the DOOPT II sensor calibration values: Press CALIB button. Result: The DO SENSOR PARAMETERS screen opens.

DO SENSOR PARAMETERS

clhp

26.00

clht

20.0

clzp

59.00

clzt

20.0

calp

1000

SET

BACK

- Enter the five DOOPT II calibration values listed on the Cellbag label.
- Note:**
- The values in the illustration above are examples only and should not be used.*
- Press **SET** to save the entered values and close the screen. The button **BACK** will close the screen without saving any changes.
 - Press the **ON/OFF** button to the left to start dissolved oxygen measurement.

Result: The button changes to green and displays **ON**.

Step	Action
------	--------

3	View signal information, if desired:
---	--------------------------------------

- Press **DETAIL** to verify the signal quality.

Result: A pop-up window displays information on the received sensor signal (amplitude and phase angle) as well as a measure of the strength of the illuminating LED light source.

DOOPT DETAIL	
Amplitude	4990
Phase	27.16
LED Current	130
BACK	

Note:

If the amplitude is outside the recommended measurement range (5000-10,000), the LED current will automatically be adjusted and the amplitude will soon return to the recommended measurement range.

4	Change DO setpoint value:
---	---------------------------

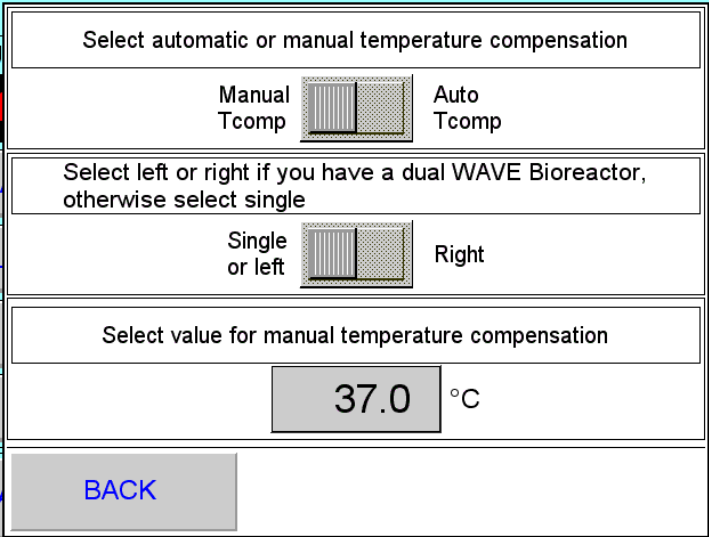
- Press the **DO SP** button.
- Enter a new setpoint (0.0-100.0% air sat) in the data entry keypad that opens.
- Press the **ENT** key to accept the new setpoint, **CLR** to clear the display and **ESC** to abort data entry.

Step	Action
------	--------

- 5

Set temperature compensation:

 - Press the **TCOMP** button.*Result:* A temperature compensation screen opens.



- Select manual (**Manual temp**) or automatic (**Auto temp**) temperature compensation.
 - Select bag position: **Single or left** or **Right**
 - If manual temperature compensation is selected, continue with next step. Otherwise, continue with calibration.
- 6

Set manual temperature value:

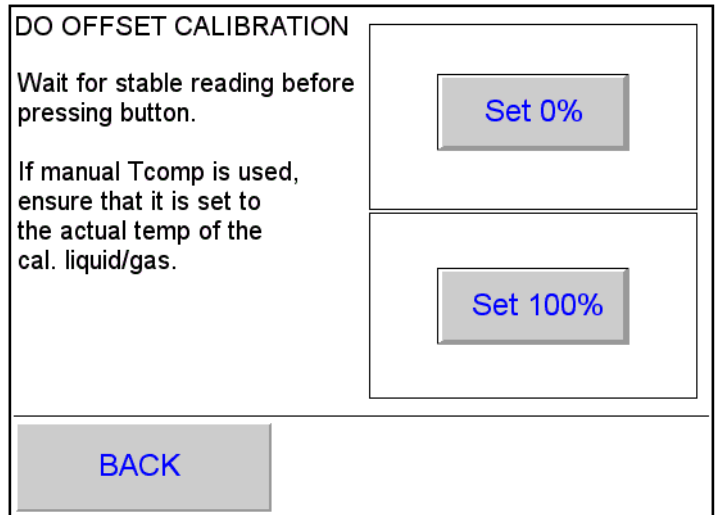
 - Press the temperature button in the temperature compensation screen.
 - Enter a new value in the data entry keypad that opens.
 - Press the **ENT** key to accept the new value, **CLR** to clear the display and **ESC** to abort data entry.

Step	Action
------	--------

7	Offset calibrate the DOOPT II sensor:
---	---------------------------------------

- Press **OFFSET**

Result: A calibration screen opens.



- Follow instructions on the screen. For details, see *DO calibration, on page 209*.
- Press **BACK** when calibration is done.

8	Select control scheme by pressing the box beside the desired mode:
---	--

- **Speed**
- **O2 concentration**
- **Speed/ O2 concentration**

9	Press ON/OFF button to the right to start dissolved oxygen (DO) control. <i>Result:</i> The button changes to green and displays ON . Information about the control is displayed on the screen.
---	--

10	When desired, press ON/OFF button to the right to stop dissolved oxygen (DO) control.
----	--

Result: The button changes to red and displays **OFF**.

Step	Action
11	When desired, press ON/OFF button to the left stop dissolved oxygen (DO) measurement. <i>Result:</i> The button changes to red and displays OFF.
Tip:	<i>During calibration the control cycle time should be short, whereas during cultivation it should be prolonged to extend the lifetime of the sensor.</i>

6.3.3 Aeration control

About aeration

Aeration control by WAVEPOD II is used for providing air mixtures containing oxygen or carbon dioxide. Non-mixed air can be provided by WAVE Bioreactor 20/50, but also by WAVEPOD II.

Location of control

Aeration control in the WAVEPOD II controller is performed from the **O2MIX CONTROL** and **CO2MIX CONTROL** screens. Aeration information and control is located on the right side of either of these screens.

Note: *There is only one air pump. Changing the airflow on the oxygen control screen, also changes the values on the carbon dioxide control screen, and vice versa.*

See Section 6.3.4 O₂ concentration control, on page 140 or Section 6.3.5 CO₂ concentration control, on page 143.

Alarm

The outlet pressure of the air from WAVEPOD II is monitored and an alarm is generated if it exceeds 12 mbar. This is to prevent overinflation of the Cellbag bioreactor.

6.3.4 O₂ concentration control

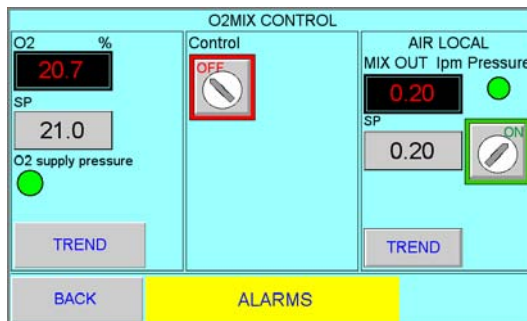
Introduction

The oxygen concentration is controlled through the **O2MIX CONTROL** screen.

Overpressure control

- If the pressure at the **MIX OUT** port exceeds 7.5 mbar due to blockage or obstruction of the air flow to Cellbag, the high pressure alarm will start blinking.
- If the overpressure condition continues for longer than 1 to 2 minutes, the airpump will shut down preventing the pressure from rising higher.
- When the overpressure condition clears the airpump will resume operation.

Oxygen control screen



The **O2MIX CONTROL** screen provides settings for oxygen mix control on the left-hand side and aeration control on the right-hand side:

Oxygen mix control:

- Actual O₂ concentration display box (**O₂ %**).
- Setpoint O₂ (**SP**) display box showing the setpoint value of O₂ concentration.
- **O₂ supply pressure** indicator. A green circle indicates sufficient supply pressure, a red circle indicates insufficient supply pressure.
- **CONTROL ON/OFF** button, start/stop oxygen control.
- **TREND** button.

Aeration control:

- Actual airflow display box (**lpm**).
- Setpoint airflow display box (**SP**).
- Airflow (**PR lpm**) indicator. A green circle indicates sufficient **MIX OUT** pressure, a red circle indicates insufficient **MIX OUT** pressure.
- **ON/OFF** button, start/stop airpump and airflow control.
- **TREND** button.

Common buttons:

- **ALARMS** button.
- **BACK** button.

Advanced option:

The O₂ setpoint can be set by the DOOPT control (**RSP, Remote Set Point**). When the option is active, a flashing message, for example **RSP from DO**, is displayed.

Instruction

Note: Air flow is required for the O₂ controller to work properly. Airflow controls are provided on the right side of the **O2MIX CONTROL** screen.

Note: There is only one air pump. Changing the airflow on the oxygen control screen, also changes the values on the carbon dioxide control screen, and vice versa.

Step	Action
1	Press the O2MIX button in the main screen (Section 6.1 WAVEPOD II main screen and general functions, on page 116). <i>Result:</i> The O2MIX CONTROL screen opens.
2	Change O ₂ setpoint value: • Press the SP display box. • Enter a new setpoint (range 21 to 50%) in the data entry keypad that opens. • Press the ENT key to accept the new setpoint, CLR to clear the display and ESC to abort data entry.
3	Press CONTROL ON/OFF button to start O ₂ control. <i>Result:</i> The button changes to green and displays ON .

6 WAVEPOD II Control system

6.3 WAVEPOD II Parameter controls

6.3.4 O₂ concentration control

Step	Action
4	Change airflow setpoint value: • Press the MIX OUT: SP display box. • Enter a new setpoint (range 0.05 to 0.5 lpm) in the data entry keypad that opens. • Press the ENT key to accept the new setpoint, CLR to clear the display and ESC to abort data entry.
5	Press AIR ON/OFF to start aeration control. <i>Result:</i> The button changes to green and displays ON.
6	When desired, press CONTROL ON/OFF button to stop O₂ control. <i>Result:</i> The button changes to red and displays OFF.
7	When desired, press AIR ON/OFF to stop aeration control. <i>Result:</i> The button changes to red and displays OFF.

6.3.5 CO₂ concentration control

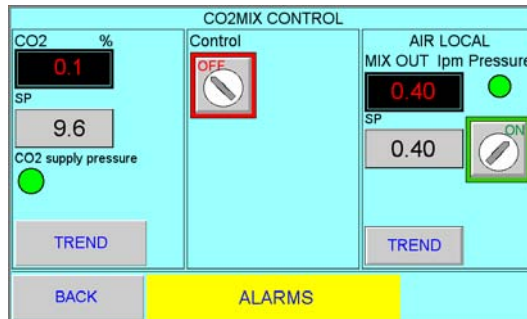
Introduction

The carbon dioxide concentration is controlled through the **CO2MIX CONTROL** screen.

Overpressure control

- If the pressure at the **MIX OUT** port exceeds 12 mbar due to blockage or obstruction of the air flow to Cellbag, the high pressure alarm will start blinking.
- If the overpressure condition continues for longer than 1 to 2 minutes, the airpump will shut down preventing the pressure from rising higher.
- When the overpressure condition clears the airpump will resume operation.

Carbon dioxide control screen



The **CO2MIX CONTROL** screen provides settings for carbon dioxide mix control on the left-hand side and aeration control on the right-hand side:

Carbon dioxide mix control:

- Actual CO₂ concentration display box (**CO₂ %**).
- Setpoint CO₂ (**SP**) display box showing the setpoint value of CO₂ concentration.
- **CO₂ supply pressure** indicator. A green circle indicates sufficient supply pressure, a red circle indicates insufficient supply pressure.
- **CONTROL ON/OFF** button, start/stop carbon dioxide control.
- **TREND** button.

Aeration control:

- Actual airflow display box (**lpm**).
- Setpoint airflow display box (**SP**).
- Airflow (**PR lpm**) indicator. A green circle indicates sufficient **MIX OUT** pressure, a red circle indicates insufficient **MIX OUT** pressure.
- **ON/OFF** button, start/stop airpump and airflow control.
- **TREND** button.

Common buttons:

- **ALARMS** button.
- **BACK** button.

Advanced option:

The CO₂ setpoint can be set by the pHOPT control (**RSP, Remote Set Point**). When the option is active, a flashing message, for example **RSP from pH**, is displayed.

Instruction

- Note:** *Airflow is required for the CO₂ controller to work properly. Airflow controls are provided on the right-hand side of the **CO2MIX CONTROL** screen.*
- Note:** *There is only one air pump. Changing the airflow on the oxygen control screen, also changes the values on the carbon dioxide control screen, and vice versa.*

Step	Action
1	Press the CO2MIX button in the main screen (Section 6.1 WAVEPOD II main screen and general functions, on page 116). <i>Result:</i> The CO2MIX CONTROL screen opens.
2	Change CO ₂ setpoint value: • Press the SP display box. • Enter a new setpoint (range 0 to 15%) in the data entry keypad that opens. • Press the ENT key to accept the new setpoint, CLR to clear the display and ESC to abort data entry.
3	Press CONTROL ON/OFF button to start CO ₂ control. <i>Result:</i> The button changes to green and displays ON .

Step	Action
4	Change airflow setpoint value: • Press the MIX OUT: SP display box. • Enter a new setpoint (range 0.05 to 0.5 lpm) in the data entry keypad that opens. • Press the ENT key to accept the new setpoint, CLR to clear the display and ESC to abort data entry.
5	Press AIR ON/OFF to start aeration control. <i>Result:</i> The button changes to green and displays ON.
6	When desired, press CONTROL ON/OFF button to stop CO₂ control. <i>Result:</i> The button changes to red and displays OFF.
7	When desired, press AIR ON/OFF to stop aeration control. <i>Result:</i> The button changes to red and displays OFF.

6.3.6 WAVE Bioreactor instrument remote control

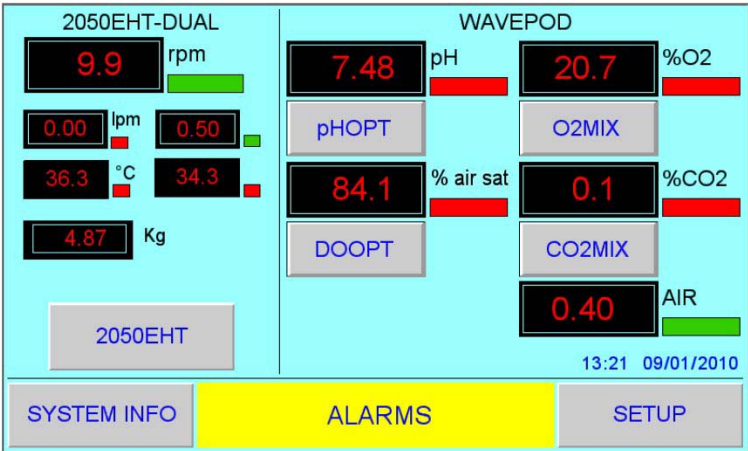
Introduction

WAVEPOD II controls the WAVEPOD II modules, as described earlier in this chapter. Additionally, the WAVE Bioreactor 20/50 instrument can be controlled remotely from WAVEPOD II. If the WAVE Bioreactor instrument is connected and operating, overview data are displayed on the left side of the WAVEPOD II main screen (Section 6.1 WAVEPOD II main screen and general functions, on page 116).

Using this function, most of the settings made for WAVE Bioreactor 20/50 and all settings made for WAVEPOD II are performed on the WAVEPOD II Touch screen. The WAVE Bioreactor Touch screen will only be used for advanced settings.

Open the instrument control screen

Step	Action
1	Connect the WAVE Bioreactor instrument to the WAVEPOD II instrument as described in Section 4.4 Installation of WAVEPOD II, on page 72. Result: Instrument parameter information and an instrument button are displayed in the left part of the WAVEPOD II main screen.



Step	Action
2	Press the WAVE Bioreactor 20/50 instrument button (2050EHT) on the main screen to reach the control screen. Result: The instrument control screen opens. In this example, a dual instrument is connected.

WAVE 20/50EHT DUAL CONTROL					
SPEED rpm		AIR L lpm		AIR R lpm	
3.9		0.00		0.49	
					
SP		SP		SP	
4.0		0.50		0.50	
TREND		TREND		TREND	
ANGLE°		TEMP L °C		TEMP R °C	
6.0		36.4		39.2	
					
WEIGHT kg		SP		SP	
4.89		37.0		37.0	
TREND		TREND		TREND	
BACK		ALARMS		BAG	

Note:

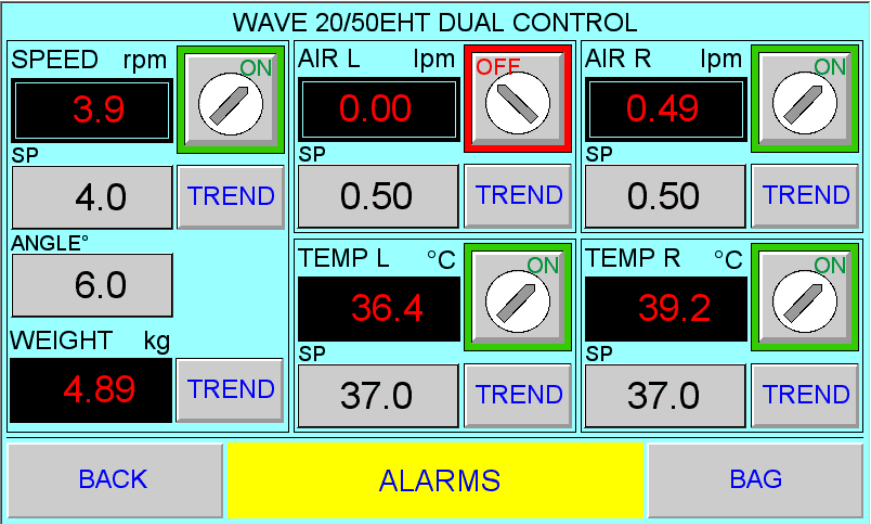
The parameters displayed in the instrument control screen depend on the instrument configuration.

Note:

Weight control is present only if the WAVE Bioreactor instrument is configured with a loadcell. However, only the weight value is shown, perfusion control must be controlled via the WAVE Bioreactor instrument.

Instrument control screen

WAVEPOD II can control rocking, airflow, and temperature of WAVE Bioreactor 20/50 remotely. The weight is remotely displayed, but not controlled.



Control box/button	Function
<i>SPEED rpm , AIR lpm , TEMP °C , WEIGHT kg</i>	Actual value
<i>SP</i>	Setpoint value
<i>ANGLE°</i>	Setpoint rocking angle value
<i>OFF/ON</i>	Control status
<i>TREND</i>	View 10 min graph
<i>BACK</i>	Return to overview screen
<i>BAG</i>	Set Cellbag size(s)

Parameter value intervals

Parameter	Interval
speed	2 - 40 rpm
angle	2 - 12°

Parameter	Interval
airflow	0 - 1.0 lpm
temperature	0°C - 45°C. Note: <i>No cooling available. Recommended min temp is ambient temperature + 5°C, recommended max temp is 40°C.</i>
weight	0.2 - 25 kg Note: <i>The weight cannot be controlled by WAVEPOD II. The value is for display only.</i>

Bag selection

- Press **BAG** button on the Instrument control screen.
- Press the arrows to select bag size (sizes) currently used.
- Press **BACK** button.



Note: For Dual mode it is possible to select two Cellbag bioreactors if of small size. For Rocker tray 20 in Dual mode two bag sizes are available, 2 L and 10 L, and for Rocker tray 50 in Dual mode the 22 L bag is available. If one large Cellbag bioreactor is selected, only the information corresponding to the left side will be shown.

Remote control instruction

Follow the general instructions below to control a parameter remotely.

Step	Action
1	Change setpoint value (not angle), if desired: • Press the SP box in the desired section. • Enter desired value in the data entry keypad that is shown. • Press ENT button to set the new value and return to the INSTRUMENT CONTROL screen.
2	Change angle setpoint value, if desired: • Press the ANGLE° box in the desired section. • Enter desired value in the data entry keypad that is shown. • Press ENT button to set the new value and return to the INSTRUMENT CONTROL screen.
3	To turn on the control, press the OFF button in the desired section.
4	To turn off the control, press the ON button in the desired section.
5	Press the TREND button to view a graph of the parameter in the desired section for the last 10 minutes, if desired.

6.4 Alarms

Introduction

The alarms are handled in the **ALARM LOG** screen.

The alarm history is retained until the unit is shutdown or a power failure occurs.

Alarm indication

A new alarm is indicated by:

- The red **ALARMS** button on the bottom of the displayed screen flashes.
- An audible beeper sounds.

Once the **ALARM LOG** screen has been opened, the alarm is acknowledged and the **ALARMS** button turns yellow and stops flashing.

Tip: *The beeper can be disabled (**ALM BEEPER OFF**) from the **SETUP OPTIONS** screen, see Section 6.5 Change operation settings, on page 154.*

Alarm log screen information

On the **ALARM LOG** screen each alarm is recorded. Each alarm message has:

- The date and time the alarm occurred or when it was cleared.
- Alarm number
- Alarm description
- Alarm status (red= unacknowledged alarms, blue=reviewed and acknowledged alarms, green=cleared alarms)

All alarms have a specified code and are time-stamped to facilitate troubleshooting (see *Alarm messages*, on page 242).

To handle an alarm

Follow the instructions below to view and acknowledge an alarm.

- | Step | Action |
|------|--|
| 1 | <p>In the MAIN MENU screen, press the ALARMS button.</p> <p><i>Result:</i> The ALARM LOG screen opens. This action also acknowledges the alarm.</p> |

ALARM LOG					13:04 09 / 01 / 2010	
SET	CLR		DESCRIPTION			
5	09/01/10	13:03		E04 EHT TEMP DEV		
4	09/01/10	13:02		E16 EHT RGHT TEMP DEV		
3	09/01/10	12:56	12:57	E21 EHT LOW WEIGHT		
2	09/01/10	12:04		04 UNICORN COMM FAIL		
1	09/01/10	12:04	12:56	E21 EHT LOW WEIGHT		

BACK

Touch alarm message for help and to acknowledge

UNACK ALM
ACK ALM
CLEARED

- | | |
|---|---|
| 2 | Use the up and down scroll arrows to page through the alarm log. |
| 3 | <p>Press the alarm message to review an alarm.</p> <p><i>Result:</i> A window opens with more information about the alarm. The alarm message turns blue indicating that the alarm has been viewed.</p> |
| 4 | <p>The ALARM LOG can be reviewed at any time by pressing the ALARMS button from the main screen (Section 6.1 WAVEPOD II main screen and general functions, on page 116) or by pressing the REVIEW ALARMS button in the SYSTEM INFORMATION screen.</p> |

To view alarm log

To view the alarm log:

- Press **ALARMS** button in the main screen or
- Press **REVIEW ALARMS** button in the **SYSTEM INFO** screen.

Clear alarm log

It is possible to clear the alarm log permanently, see *Section 6.5 Change operation settings, on page 154*.

6.5 Change operation settings

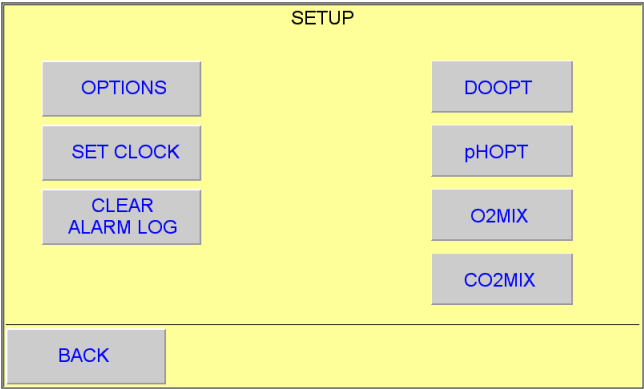
Introduction

Settings for alarms, deadbands at parameter controls etc. can be changed from the **SETUP** screen.

Enter the SETUP screen

Step	Action
1	Press SETUP button in the MAIN MENU screen (Section 6.1 WAVEPOD II main screen and general functions, on page 116). <i>Result:</i> A password entry screen opens. Password prevents unauthorized personnel from accessing SETUP parameters. The default password is 2050. SETUP access password Enter password ***** BACK
2	• Press the **** button. • Enter the password. • Press ENT. <i>Result:</i> The SETUP screen opens. Options available in the SETUP screen depends on the specific system configuration.

SETUP screen



Press	in order to
<i>OPTIONS</i>	set WAVE Bioreactor 20/50 type, auto start after power failure (on/off), auto acknowledge of Alarms (on/off) and Alarm beeper (on/off).
<i>SET CLK</i>	set instrument time.
<i>CLEAR ALARM LOG</i>	clear the stored alarm log. The cleared alarm log cannot be retrieved.
<i>DOOPT</i>	set various DO parameters.
<i>pHOPT</i>	set various pH parameters.
<i>O2MIX</i>	set various O ₂ parameters.
<i>CO2MIX</i>	set various CO ₂ parameters.

Set instrument type and autostart and alarm options

This setup screen is reached by pressing the **OPTIONS** button.

OPTIONS	
WAVEPOD Auto Start OFF ☐ ON Auto Ack OFF ☐ ON UNICORN Data Acquisition OFF ☐ ON Alarm Beeper OFF ☐ ON	WAVE Bioreactor Instrument type (click to change) ↑ 2050EHT_SINGLE ↓ Auto Start OFF ☐ ON Auto Ack OFF ☐ ON
BACK	

In the **OPTIONS** screen it is possible to set:

- Type of WAVE Bioreactor 20/50 instrument (options available; **2050EHT_SINGLE**, **2050EHT_DUAL**, **2050EHT_CO2**, **2050EHT_O2** and **NONE**). Click in the **Instrument type** field to display desired instrument type. The default value is **NONE**.
- Auto Start ON/OFF** for both WAVEPOD II (**WAVEPOD**) and WAVE Bioreactor 20/50 instrument (**WAVE Bioreactor**). To change setting, click the switch symbol for desired setting. When this setting is enabled (**ON**), the instrument starts in the same state as at the time of the last shutdown or power loss. The default value is **ON**.
- Auto Ack ON/OFF** for both WAVEPOD II (**WAVEPOD**) and WAVE Bioreactor 20/50 instrument (**WAVE Bioreactor**). To change setting, click the switch symbol for desired setting. Normally the user must acknowledge any new alarm by pressing the **ALARMS** button to view the alarm history screen. If the **Auto Ack** feature is set to **ON** all alarms are automatically acknowledged. No warnings are generated but the alarm is still logged. The default value is **OFF**.
- UNICORN DAQ Data Acquisition ON/OFF**. To change setting, click the switch symbol for desired setting. This must be enabled when installing the Converter 100 and when using UNICORN DAQ during a cultivation.
- Alarm beeper** for WAVEPOD II. To change setting, click the switch symbol for desired setting. The default value is **ON**.

Set time

This setup screen is reached by pressing the **SET CLOCK** button.

SET CLOCK

NEW TIME AND DATE

Hour:Minute
1316
Month/Day/Year
912010

CURRENT TIME AND DATE

Hour:Minute:Second
13:16:31
Month/Day/Year
09/01/2010

BACK

In the **SET CLOCK** screen it is possible to set time for the WAVEPOD II instrument (**Hour:Minute** and **Month/Day/Year**). Current time is displayed to the right. Press desired time parameter box to change time. Click **BACK** when desired time has been set.

Clear alarm log

Pressing the **CLEAR ALARM LOG** button will clear the stored alarm log. Avoid accidental pressing of the the **CLEAR ALARM LOG** button since the alarm log can not be retrieved after pressing this button.

Common parameter control setups

In the control setup screens for DO, pH, O2 and CO2, there are several common controls. These are explained in the table below.

Control	Description
DEV alarm	Deviation alarm. If this parameter is set to OFF , then deviations from the setpoint will not be monitored. Default: ON . Available for DO, pH, O ₂ and CO ₂ .

Control	Description
DEV limit	Deviation limit. Sets the DO/pH/O2MIX/CO2MIX deviation alarm borders. A deviation alarm is triggered if the parameter value is different from the setpoint by +/- this amount. The deviation alarm is only active if DEV alarm is ON and the desired controller is ON . Available for DO, pH, O ₂ and CO ₂ .
DBAND	Deadband. Control action will not take place if the parameter value is within the deadband. Increasing the deadband will result in coarser control. Available for DO and pH. For pH control using CO₂, the deadband is defined as pH units +/- the setpoint. For pH control using acid/base, it is defined as % of cycle time. The amount of added acid or base is controlled by turning the pump on (at a fixed rate) for a certain percentage of the time in each control cycle. By setting a deadband percentage, a lower limit on all acid/base additions is set, so that if the addition asked for by the pH control is lower than the deadband value, no addition is made. Both different deadband values must be entered when applying the CO₂/base control scheme. For more information, see <i>Section B.2 pH measurement and control</i>, on page 257.

DO and pH control setup buttons

The following buttons are provided for DO and pH regulation on their respective setup screens. Press them to reach detail screens.

- Set control times
- Transition delay
- Info/Help

Set control times

In the Control cycle screens, the sampling interval is set. This is identical to the control cycle time. After each control action, the controller must wait for a defined control cycle time in order to let the change from the last control action to result in a stable new measurement.

If the sampling time and hence the control time is set too short, then the controller may overcompensate. If it is set too long, then the parameter may not be controlled properly and drift. See also *Set pH control parameters, on page 191*.

DO screen	pH screen
DO CONTROL CYCLE AND SAMPLING INTERVAL DO Control Cycle O2 s 200 SPEED s 120 The control cycle parameter sets how often the controller is executed. The parameter also sets the sampling interval which is equal to the control cycle. The controller will execute directly after every new measurement. For O2 and SPEED the control cycle can be 30 to 1000 seconds. Consult the tables in the manual for suitable control cycle times, P and I-parameters for your setup. BACK	pH CONTROL CYCLE AND SAMPLING INTERVAL pH Control Cycle Acid/Base s 60 CO2 s 330 The control cycle parameter sets how often the controller is executed. The parameter also sets the sampling interval which is equal to the control cycle. The controller will execute directly after every new measurement. For CO2 the control cycle can be 30 to 1000 s, for ACID/BASE 30 to 500 s. Consult the tables in the manual for suitable control cycle times, P and I-parameters for your setup. BACK

Transition delay

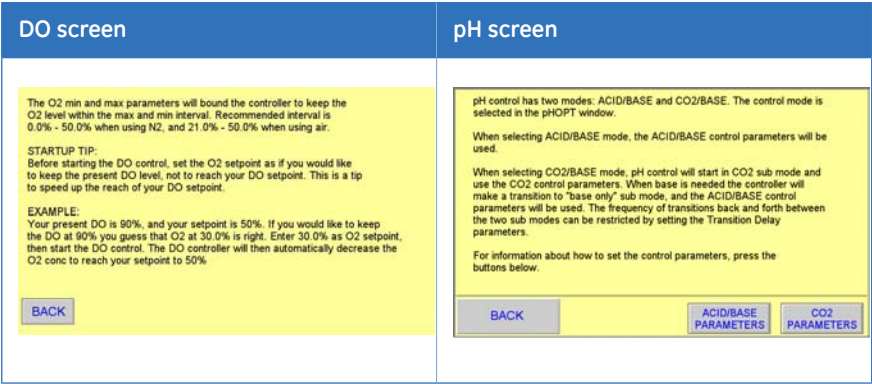
In the transition delay screen, the delay time for avoiding unnecessary toggling between different control modes is set. For more information, see *Section B.2 pH measurement and control, on page 257*, and *Section B.3 DO measurement and control, on page 261*.

Note: *It is recommended that transition delay times should be set to more than 15 times longer than the control cycle times. Note that transition delay times are set in minutes, and control cycle times in seconds.*

DO screen	pH screen
- Delay between O2 and speed - Delay between speed and O2 O2/SPEED Transition Delay O2 -> SPEED (minutes) 120 SPEED -> O2 (minutes) 120 The Transition Delay settings are only used in the O2/SPEED control mode. No transitions will take place in the other two control modes. The parameters set the delay of the transition from one control sub mode to the other. The delay is there to prevent unnecessary toggling between the control sub modes. BACK	- Delay between CO2 and base - Delay between base and CO2 CO2/BASE Transition Delay CO2 -> BASE (minutes) 120 BASE -> CO2 (minutes) 60 The Transition Delay settings are only used in the CO2/BASE control mode. The parameter sets the delay of the transition from one control sub mode to the other. The delay is there to prevent unnecessary toggling between the control sub modes. BACK

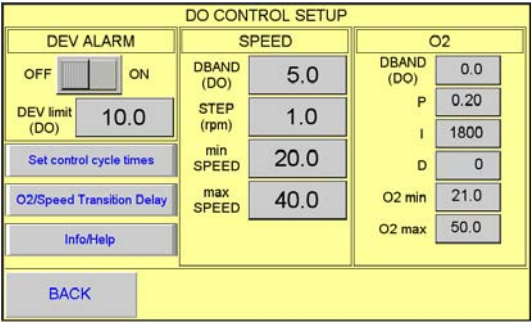
Info/Help

This screen provides information about the control schemes. Additional buttons in the pH info screen open new screens with detailed information about the individual control parameters.



DO control setup screen

This control setup screen is reached by pressing the **DOOPT** button in the **SETUP** screen.



In the **DO CONTROL SETUP** screen it is possible to set an alarm, speed control, oxygen control and common control parameters. The control scheme (speed, oxygen or speed/oxygen) is selected in the **DOOPT** screen, see *Section 6.3.2 Dissolved oxygen control, on page 130*.

The left hand side provides:

- Deviation alarm (**DEV alarm**), **ON/OFF**
- Deviation limits (**DEV limit**), range 0% to 10% (default 10%)
- **Set control cycle times** button, range 10 to 999 seconds
- **O2/Speed Transition delay** button, parameters for how to toggle between the control mechanisms
- **Info/Help** button
- **BACK** button

The center of the screen provides settings used when controlling DO using rocking speed:

- Dead band range for DO (**DBAND**), range 0% to 100% air sat

- **STEP** (rpm) defines the how quickly the controller changes the rocking speed per cycle, range up to 10.0 rpm/cycle
- lower speed limit during regulation (**min SPEED**), range 2 to 40 rpm
- upper speed limit during regulation (**max SPEED**), range 2 to 40 rpm

The right hand side provides settings used when controlling DO using O₂:

- Dead band range for DO (**DBAND**), range 0% to 100% air sat
- PID-regulator values (**P**, **I** and **D**) define how the controller changes the O₂ concentration setting per cycle.
- lower concentration limit during regulation (**O2 min**), range 0.0% to 50.0% O₂
- upper concentration limit during regulation (**O2 max**), range 0.0% to 50.0% O₂

Default values

The default control parameter values that are pre-installed at manufacture are given in the table below.

Parameter		Default value
DEV ALARM		OFF
DEV limit		10.0
SPEED	DBAND	5.0
	STEP	1.0
	min SPEED	20.0
	max SPEED	40.0
O2	DBAND	0.0
	P	0.20
	I	1800
	D	0
	O2 min	21.0
	O2 max	50.0
DO Control cycle	O2	200
	SPEED	120
O2/SPEED Transition delay	O2->SPEED	120
	SPEED->O2	120

pH control setup screen

This control setup screen is reached by pressing the **pHOPT** button in the **SETUP** screen.

pH CONTROL SETUP			
DEV ALARM		ACID/BASE	
OFF ☐	ON ☒	DBAND (%)	2.0
DEV limit (pH)	0.10	P	0.70
Set control cycle times		I	3000
CO2/BASE Transition Delay		D	0
Pump Calibration		Acid gain	1.0
		Base gain	1.0
		DBAND (pH)	0.00
		P	0.35
		I	4100
		D	0
		CO2 min	0.0
		CO2 max	15.0
BACK		Info/Help	

In the **pH CONTROL SETUP** screen it is possible to set an alarm, acid/base control settings, carbon dioxide control settings and common regulating parameters. The control scheme (acid/base or CO2/base) is selected in the **pHOPT** screen, see *Section 6.3.1 pH control, on page 121*.

The left hand side provides:

- Deviation alarm (**DEV alarm**), **ON/OFF**
- Deviation limits (**DEV limit**), range 0.0 to 1.0 pH unit
- **Set control cycle times** button.
- **CO2/base Trans. Delay** button, parameters for how to toggle between the control mechanisms
- **Pump Calibration** button, see *Pump flow calibration, on page 193*
- **BACK** button
- **Info/Help** button

The center of the screen provides settings used when controlling pH using the acid/base control mechanism:

- Deadband range for acid/base additions (**DBAND**), range 0% to 10% of cycle time
- PID-regulator values (**P**, **I** and **D**) define how the controller changes the acid/base additions per cycle
- Acid gain (**ACID GAIN**), multiplier that affects the active pump time as part of the cycle time, range 0 to 10
- Base gain (**BASE GAIN**), multiplier that affects the active pump time as part of the cycle time, range 0 to 10

The right hand side provides settings used when controlling pH using the CO2 control mechanism:

- Dead band range for pH (**DBAND**), range 0.0 to 1.0 pH units. It is recommended that this value is set to 0.0.
- PID-regulator values (**P**, **I** and **D**) define how the controller changes the CO₂ concentration setting per cycle.
- lower concentration limit during regulation (**CO2 min**), range 0.0% to 15.0% CO₂
- upper concentration limit during regulation (**CO2 max**), range 0.0% to 15.0% CO₂

Default values

The default control parameter values that are pre-installed at the factory are given in the table below.

Parameter		Default value
DEV ALARM		OFF
DEV limit		0.10
ACID/BASE	DBAND	2.0
	P	0.7
	I	3000
	D	0
	Acid gain	1.0
	Base gain	1.0
CO2	DBAND	0.00
	P	0.35
	I	4100
	D	0
	CO2 min	0.0
	CO2 max	15.0
pH Control cycle	Acid/Base	60
	CO2	330
CO2/BASE Transition delay	CO2->BASE	120
	BASE->CO2	60

Note: In order to reduce the effect to photobleaching, it is recommended to select the sample interval such that the total number of pH sampling measurements is approximately 40,000 at most.

O₂ control setup screen

This control setup screen is reached by pressing the **O₂ MIX** button in the **SETUP** screen.

O2MIX CONTROL SETUP	
O2	AIRFLOW
DEV Alarm: OFF ON	DEV alarm: OFF ON
DEV +/- limit O2%: 2.0	AIR PV: 0.00
O2 PV: 20.7	SCALING (ml/min): 1000
O2 offset: -0.2	AIR SP: 0.30
BACK	

In the **O₂MIX CONTROL SETUP** screen it is possible to:

- Set O₂ concentration deviation alarm (**DEV alarm**), **ON/OFF**.
- Set O₂ deviation limits (**DEV limit**) range 0.0% to 5.0%.
- View actual O₂ concentration (**O₂ PV**).
- Set **O₂ OFFSET**, small adjustments of O₂ concentration settings can be made by changing the offset.
- Set airflow deviation alarm (**AIRFLOW DEV alarm**), **ON/OFF**. Deviation alarm limit is fixed at 0.02 lpm.
- Set **SCALING (mL/min)**: Small airflow adjustments can be made by changing the scaling.
- Set airflow set point (**AIR SP**) range 0.0 to .

Note: Contact GE Healthcare for adjustment service, if necessary.

CO₂ control setup screen

This control setup screen is reached by pressing the **CO2MIX** button in the **SETUP** screen.

CO2MIX CONTROL SETUP	
CO2	AIRFLOW
DEV Alarm ☐ OFF ☐ ON	DEV alarm ☐ OFF ☐ ON
DEV +/- limit CO2% 1.0	AIR PV 0.00
CO2 PV 0.0	SCALING (ml/min) 1000
CO2 offset 0.0	AIR SP 0.30
BACK	

In the **CO2MIX CONTROL SETUP** screen it is possible to:

- Set CO₂ concentration deviation alarm (**DEV alarm**), **ON/OFF**.
- Set CO₂ concentration deviation limit (**DEV limit**), range 0.0% to 5.0%.
- View actual CO₂ concentration (**CO2 PV**).
- Set **CO2 OFFSET**, small adjustments of CO₂ concentration settings can be made by changing the offset.
- Set airflow deviation alarm (**AIRFLOW DEV alarm**), **ON/OFF**. Deviation alarm limit is fixed at 0.02 lpm.
- View actual airflow (**AIR PV**).
- Set **SCALING (mL/min)**: Small airflow adjustments can be made by changing the scaling.
- Set airflow (**AIR SP**).

Note: Contact GE Healthcare for adjustment service, if necessary.

7 UNICORN DAQ 1.0 software

About this chapter

This chapter describes the UNICORN DAQ 1.0 software, which is used for data acquisition from the cell cultivation.

In this chapter

Section	See page
7.1 UNICORN DAQ 1.0 introduction	167
7.2 UNICORN DAQ modules	169

7.1 UNICORN DAQ 1.0 introduction

Introduction

This section gives a brief overview of UNICORN DAQ 1.0 — a software for data acquisition, logging and evaluation of cultivations. It also describes how to access the help utility that is included in UNICORN DAQ.

For detailed information about the software, read UNICORN DAQ 1.0 - User manual for WAVE Bioreactor.

UNICORN DAQ modules overview

UNICORN DAQ 1.0 consists of three modules: **Administration**, **System Control** and **Evaluation**. The main functions of each module are described in the table below.

Module	Main functions
<i>UNICORN Manager</i>	Perform user and system setup, file handling and administration.
<i>System Control</i>	Start and view runs.
<i>Evaluation</i>	Open results, evaluate cultivations and create reports.

Enter a UNICORN DAQ module

To enter a module:

- click the **Taskbar** button of the module of interest,



or

- click the corresponding toolbar icon in the **UNICORN Manager** module:



Evaluation module



System Control module

or

- select the module of interest from the **Tools** menu in the **UNICORN Manager** module.
-

7.2 UNICORN DAQ modules

UNICORN Manager module

The **UNICORN Manager** module is mainly used to perform user and system setup, and file and folder administration. Results may also be opened by double-clicking on the file in the **Results** window. The Manager module is not described in this manual. For information, read UNICORN DAQ 1.0 - User manual for WAVE Bioreactor.

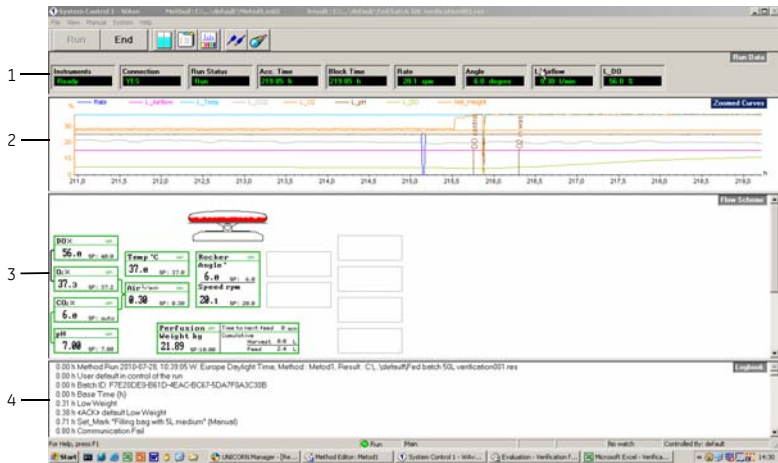
System control module

Introduction

The **System Control** module is used to monitor and store data from the cell culture process. This section only gives a brief overview of the functions. For further information, read UNICORN DAQ 1.0 - User manual for WAVE Bioreactor.

System Control panes

Up to four panes may be viewed in the **System Control** module. The **Run Data** pane (1) presents current data in numerical values, while the **Curves** pane (2) illustrates data as curves during the entire cultivation. The **Flow Scheme** pane shows system configuration and the status of system components (3). Recorded events, such as data acquisition start, end, manual instructions and errors are presented in the **Run Log** (4).



System Control toolbar icons

The table below shows the **System Control** toolbar icons.

Icon	Function	Icon	Function
	Run: Starts a method run		Connect System: Connect a WAVE Bioreactor system
	End: Permanently ends the method run		Disconnect System: Disconnect the WAVE Bioreactor system
	Customize Panes: Opens the Customize panes dialog		Take Control of System: Leaves view mode and changes to control mode so that manual instructions can be issued
	View Documentation: Opens the run documentation pages		Leave Control of System: Leave control mode and enter view mode
	View Properties: Opens the Properties dialog		

- Note:** *The **Run** icon can only be used if*
- a template method has been previously chosen using **File:Instant Run***
and
 - UNICORN has not been closed since the previous acquisition*

Quick start guide

The instruction below describes the easiest way to start data collection from WAVE Bioreactor and generate a printed report. For more details on data acquisition and evaluation of run data, refer to the UNICORN DAQ 1.0 - User manual for WAVE Bioreactor.

Step	Action
1	In the System Control module, select File:Instant Run . <i>Result:</i> The Instant run dialog box opens

Step	Action
2	- Select a system (if several WAVE Bioreactor systems are available) - Make sure that Template is selected - Choose the template method in the Template list - Click the Run button <i>Result:</i> Data acquisition begins and can be monitored in the System Control module Curves pane
3	Click the End icon in the System Control module to stop data acquisition. <i>Result:</i> A dialog opens asking for confirmation before saving the partial result.
4	Click the OK button to save the result.
5	When desired, click End to end data acquisition.
6	In the Evaluation module: - Locate and select the result file in the Recent Runs list. - Click the Report icon:  - Choose a report format and click OK. <i>Result:</i> The preformatted report is displayed in the Evaluation module.
7	Click the Print icon:  <i>Result:</i> The report is printed.

Monitor cultivation

The following table contains brief instructions for some common operations in the **System Control** module. For more details, refer to UNICORN DAQ 1.0 - User manual for WAVE Bioreactor.

If you wish to...	Then...
select curves to be displayed	• Select View:Properties • Select the Curves tab in the Properties dialog • Select the curves to be displayed in the Display curves list • Click OK
display a vertical marker line	• Right click the Curves pane and select Marker • Drag the marker line with the mouse
change Y-axis scale	• Select View:Properties • Select the Y-axis tab • Select the appropriate curve • Select Fixed and enter a range in the fields
change X-axis scale	• Select View:Properties • Select the X-axis tab • Select the desired Axis scale
zoom in the Curves pane	• Press and hold the left mouse button and drag a rectangle over the area to be viewed • Release the mouse button to zoom in • To undo or reset the zoom, right-click in the Curves pane and select Undo Zoom or Reset Zoom

Evaluation module

Introduction

The **Evaluation** module is used to open results, evaluate cultivations and create reports. This section only gives a brief overview of the functions. For further information, read UNICORN DAQ 1.0 - User manual for WAVE Bioreactor.

Evaluation toolbar icons

The table below shows the **Evaluation** toolbar icons.

Icon	Function	Icon	Function
	Open: Displays all available result files and folders in the Open Result dialog.		Report: Opens the Generate report dialog where a report of the result can be created.
	Open Curves to Compare: Opens the Open Curves to Compare dialog where multiple curves can be selected for comparison.		View Documentation: Opens the Documentation dialog that contains the complete documentation for a cultivation.
	Save: Saves the changes made to the current result.		Chromatogram Layout: Opens the Chromatogram Layout dialog where curves can be selected and formatted.
	Print: Opens the Print chromatograms dialog from where curves can be printed.		

View cultivation results

Read UNICORN DAQ 1.0 - User manual for WAVE Bioreactor for information about how to:

- open a result
- change view details (zoom in on a curve, change y axis unit, select curves to display etc.)
- create a report
- print a report

8 Operation

About this chapter

This chapter describes how to operate WAVE Bioreactor 20/50.

In this chapter

Section	See page
8.1 Operation overview	175
8.2 Starting the system	177
8.3 Assembly of system	179
8.4 Connect aeration	185
8.5 Prepare WAVEPOD II	188
8.6 Set operation control and monitoring conditions	201
8.7 Procedures before inoculation	204
8.8 Perform cultivation	212
8.9 Cultivation options	216
8.10 End cultivation	220

8.1 Operation overview

WAVE system control

Control of operation, monitoring and key parameters during cell cultivation in WAVE Bioreactor 20/50 system depends on system configuration and optional presence of WAVEPOD II and stand-alone instruments.

The basic functions of the control systems are described in *Chapter 5 WAVE Bioreactor control system, on page 83* and *Chapter 6 WAVEPOD II Control system, on page 115*. For information about control systems of stand-alone modules, see *Stand-alone instruments for WAVE Bioreactor 2/10 and 20/50 Operating Instructions*.

Workflow

Stage	Description
1	Assemble system components - Assemble Heater pad, Rocker tray and temperature sensor - Optional: Connect WAVEPOD II and/or other stand-alone instruments - Assemble Cellbag and connect optical fibers if applicable - Connect aeration (including optional O₂ and/or CO₂ gas supply) and, optional, acid/base or feed/harvest tubing to Cellbag bioreactor(s) as well as any optical fibers
2	Prepare system for cultivation - Start system components including optional WAVEPOD II and/or stand-alone instruments - Inflate Cellbag - Fill Cellbag with culture medium - Set cultivation conditions - Equilibrate Cellbag - Calibrate and adjust sensors

Stage	Description
3	Start cultivation • Inoculate Cellbag • Monitor and control culture conditions • Calibrate and adjust sensors
4	Optional actions during cultivation • Take sample from the culture • Offset calibration of optical sensors • Exchange culture medium • Scale up culture
5	End cultivation • Harvest • After run procedures

8.2 Starting the system

Instruction



CAUTION

During initialization, the Rocking plate tilts back and forth. Keep distance.

Follow the instruction below to turn on the system.

Step	Action
1	Make sure that any desired stand-alone instruments are correctly installed.
2	Turn the WAVE Bioreactor instrument power switch on (I). It is located at the rear of the instrument. <i>Result:</i> The WAVE Bioreactor instrument initializes. The Rocking plate of the WAVE Bioreactor instrument starts tilting slowly towards the rear. It contacts the rear safety switch (white touchbar) and then move towards the front until it hits the front safety switch. The Rocking plate then moves to the sampling position and stops. After initialization, the main screen is displayed on the Touch screen. Tip: The Touch screen can be angled for ease of viewing, or detached and mounted remotely. The Touch screen cable is a standard telephone-type cable. Note: <i>If the safety switch is hit, the rocking motion stops and the rocking unit moves to a level position.</i> Note: <i>If the safety switches have been hit, power must be turned off (O) and on (I) to reset the safety switch.</i>
3	Optional: Turn desired installed stand-alone instrument power switches on (I).

Step	Action
4	Optional: Turn on UNICORN DAQ 1.0: • Turn on the computer hosting UNICORN DAQ 1.0. • Turn on the Converter 100. • Start the software from the Microsoft™ Windows™ Start menu or by double-clicking the desktop icon. • Log on to the software.

8.3 Assembly of system

Assembly of the Heater pad, Rocker tray and temperature sensor

If the Heater pad, Rocker tray and temperature sensor are not in place, follow the instruction to assemble them in *Setting up the Rocker tray and temperature control system*, on page 61. For details concerning the available Rocker tray sizes, refer to *Rocker tray and Cellbag bioreactor*, on page 53.

Prepare pH and/or DO control

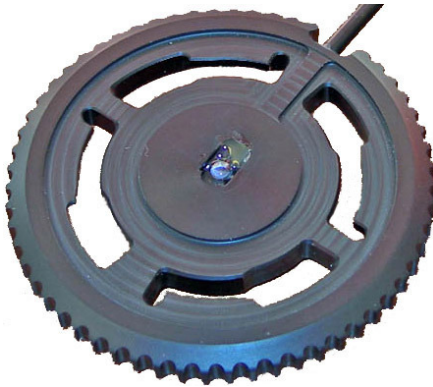


NOTICE

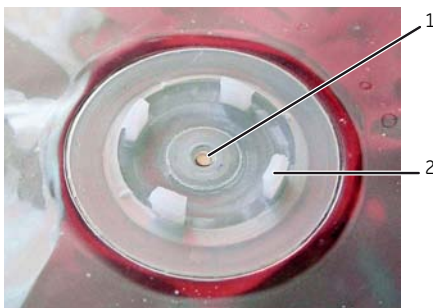
Do not open the bag before you enter the production room. Remove the black inner protective bag immediately before use.

Optical sensor parts

The bag adaptor for coupling to an optical bag port (pHOPT or DOOPT II) is located at one end of an optical fiber cable. The optical lens of the fiber cable is in the center of the bag adaptor. See illustration below.



Below is an illustration of an optical bag port, which is located in the bottom of a Cellbag bioreactor configured with optical sensors. The sensor is the small dot in the center (1) of the bag port (white for pHOPT, pink/black for DOOPT II). The bag adaptor is attached to the sensor bag port by the four pins (2).



Connect the optical fiber to the Cellbag bioreactor



NOTICE

Intense light will deteriorate the optical sensors. To avoid unnecessary illumination of the optical sensors, remove the protective black bag just prior to use.

Step	Action
1	Flip Cellbag bioreactor and place it with the down side faced up on a steady surface.
2	Identify the pHOPT and/or DOOPT II sensor bag ports. The pHOPT sensor is white, while the DOOPT II sensor is pink. Labels are also provided adjacent to the bag ports for identification. If both pHOPT and DOOPT II sensors are used one fiber cable is needed for each sensor. Keep track of the fiber cables (e.g., with a piece of tape) to make sure that they are connected to the proper monitor of WAVEPOD II.
3	Attach the bag adaptor, with the optical lens facing the sensor bag port, by inserting the four pins of the bag port into the corresponding holes of the bag adaptor.



Note:

The bag adaptor can be fastened in any of four orthogonal directions. Select a direction that allows for the straightest possible routing of the fibre when the bag is placed in the tray.

Step	Action
4	Rotate the bag adaptor clockwise to fix the pins on the bag port to the bag adaptor. A distinct "click" will indicate that the adaptor is securely fastened. Route any optical fiber cables sideways out from the tray towards WAVEPOD II.



Note:
When rotating the bag adaptor, make sure not to place any force on the fiber cable.

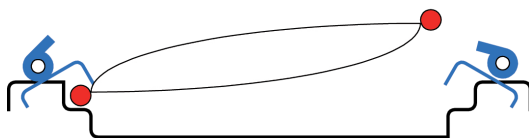
Fasten the Cellbag bioreactor(s)

Follow the instruction below to fasten the Cellbag bioreactor(s) on the Rocker tray.

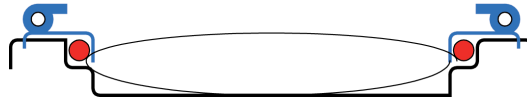
Step	Action
1	Select Cellbag size depending on experiment demands and instrument setting. For Dual operation two Cellbag bioreactors can be used.
2	Remove the selected disposable Cellbag bioreactors from the protective plastic cover bags.
3	Open the guides on the Rocker tray by lifting the cam levers located on either side of the Rocker tray.



Step	Action
4	Place the Cellbag bioreactor into the Rocker tray and push each of the two plastic rods into the corresponding open guide. Make sure that the Cellbag bioreactor is placed with the sampling ports towards the front.



Step	Action
5	Turn and press the cam levers down to lock the Cellbag bioreactor into the Rocker tray.



Note: Using any bags other than GE Healthcare Cellbag bioreactors on WAVE equipment will void any warranty or service claims.



NOTICE

It is strongly recommended that Cellbag bioreactors with built-in optical sensors are covered with a non-transparent cover, such as the optional lid or the black bag in which the Cellbag bioreactor is delivered, during cultivation, to reduce sensor aging due to light exposure.

Optional: Connect WAVEPOD II and/or stand-alone instruments

Some control functions are not available in some WAVE Bioreactor 20/50 instrument configurations. WAVEPOD II and other stand-alone instruments can be used to provide desired control functions. Connect suitable instruments not already connected to the system.

For instructions how to connect WAVEPOD II to WAVE Bioreactor 20/50, see *Section 4.4 Installation of WAVEPOD II, on page 72*. For instructions how to connect tubing etc. to WAVEPOD II, see *Section 8.5 Prepare WAVEPOD II, on page 188*.

For instructions how to connect stand-alone instruments, see *Stand-alone instruments for WAVE Bioreactor 2/10 and 20/50 Operating Instructions*.

8.4 Connect aeration

Introduction

Cellbag bioreactors require aeration to keep them inflated and to provide ventilation. The ventilation air can be room air, incubator air, or a special gas mixture, depending on the cell line and buffer system in use. WAVE Bioreactor 20/50 has an internal air pump (two in the dual version) that is used to aerate the Cellbag bioreactors.

Gas is drawn in from the **Air In** port on the WAVE Bioreactor 20/50 instrument by an internal pump and pumped out from the **Air Out** port to the Cellbag bioreactor.

Aeration can also be provided by a WAVEPOD II instrument or by a stand-alone instrument. For some configurations it is possible to set CO₂ and/or O₂ concentration in combination with aeration. For instructions of how to connect aeration between WAVEPOD II and Cellbag, see below. For instructions of how to connect aeration between a stand-alone instrument and Cellbag, see *Stand-alone instruments for WAVE Bioreactor 2/10 and 20/50 Operating Instructions*.

Illustration of air inlet and outlet

The **Air In** and **Air Out** ports on WAVE Bioreactor 20/50 are placed on the left panel. For dual instruments, ports are also placed on the right hand side.



Part	Function
1	Temp connector
2	Air Out
3	Air In

Setting up the aeration system of the bioreactor

Follow the instruction below to set up the aeration system of the bioreactor:

- Connect air inlet and air outlet according to the table below.
- Make sure both inlet and outlet filter tubing clamps are open.

For...	Then...
ambient air intake	• Connect the supplied air tube between the Air Out port located on the left side of the bioreactor and the inlet filter of the Cellbag bioreactor. • Leave the Air In port unconnected.
process air intake	• Connect the supplied air tube between the Air Out port located on the left side of the bioreactor and the inlet filter of the Cellbag bioreactor. • Connect the process air source (< 0.2 bar or 2.9 psig) to the Air In port.
CO ₂ - or O ₂ -enriched air intake using a WAVE Bioreactor 20/50 CO ₂ - or O ₂ configuration	• Connect the supplied air tube between the Air Out port located on the left side of the bioreactor and the inlet filter of the Cellbag bioreactor. • See <i>Connect CO₂ or O₂ to configured instrument, on page 187.</i>
CO ₂ - or O ₂ -enriched air intake using CO2MIX or O2MIX modules in WAVEPOD II	See <i>Section 8.5 Prepare WAVEPOD II, on page 188.</i>
CO ₂ - or O ₂ -enriched air intake using external CO2MIX20, O2MIX20, CO2MIX20-R or O2MIX20-R controllers	See manual <i>Stand-alone instruments for WAVE Bioreactor 2/10 and 20/50 Operating Instructions.</i>

Connect CO₂ or O₂ to configured instrument

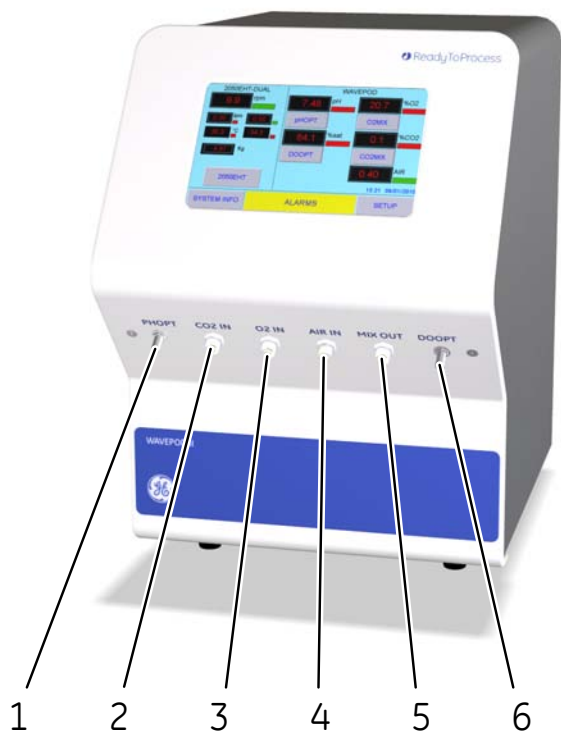
Follow the instruction below to connect carbon dioxide gas to the WAVE Bioreactor instrument when the instrument is CO₂ configured. Aeration is controlled from the instrument.

Step	Action
1	Set the external gas source (100% CO ₂ or O ₂) to between 0.7 to 1.0 bar (10 to 15 psig). Connect the gas source to the CO2 IN or O2 IN inlet connector on the side of the WAVE Bioreactor instrument.
2	Leave the Air In port unconnected if you wish to mix in ambient air with the gas stream. Alternatively, process air (< 0.2 bar or 2.9 psig) can be connected to Air In .
3	The gas/air mixture is pumped out from the Air Out port on the side panel. Connect this directly to the inlet filter on the Cellbag bioreactor.

8.5 Prepare WAVEPOD II

WAVEPOD II control ports layout

The WAVEPOD II controller is provided in several configurations. The illustration below shows an example of the ports on the front of a fully equipped WAVEPOD II.



Part	Connector name	Parameter control
1	pHOPT	pH
2	CO2 IN	CO2MIX
3	O2 IN	O2MIX
4	AIR IN	Aeration
5	MIX OUT	Aeration, CO2MIX, O2MIX
6	DOOPT	DO

Prepare pH control

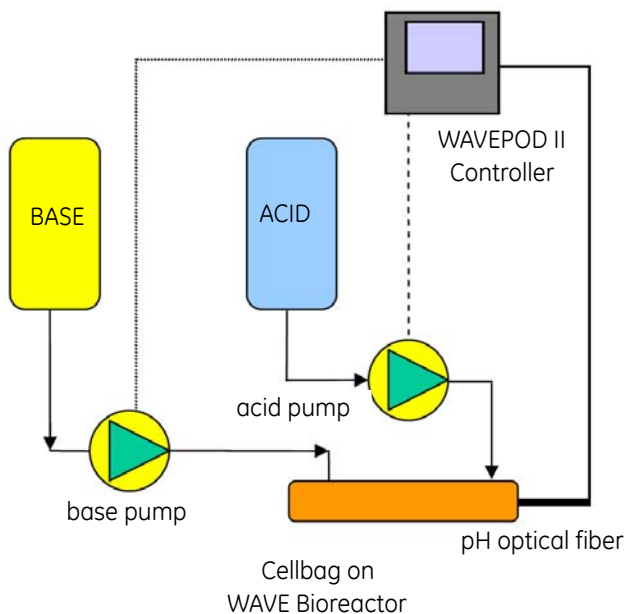
Introduction

There are two pH control modes, acid/base and CO₂/base. During preparation the desired solutions and gas are connected and the control mode is selected.

Note: pH control requires that pHOPT is part of the WAVEPOD II configuration. The CO₂/base control scheme also requires a CO2MIX module as part of the configuration.

Note: When UNICORN DAQ is used, make sure that the **pH WAVEPOD** configuration is selected to log pH readings (**UNICORN Manager: System Setup: Components**). It is recommended to also select **pH Details** to log LED, amplitude and phase angle

Illustration of pH control using acid and base



Connect pH sensor

The distal end of the optical fiber cable associated with the pHOPT sensor should already be connected to the Cellbag bioreactor, see *Connect the optical fiber to the Cellbag bioreactor*, on page 181.

Step	Action
1	Turn on the power to the instrument.

Step	Action
2	Connect an optical fiber cable to the PHOPT port on the WAVEPOD II front.

Regarding initial calibration of the pHOPT sensor, see *Offset pHOPT calibration, on page 208*.

Connect acid and base tubing

Connect base solution when you are using acid/base mode or CO₂/base mode. Connect acid solution if you are using acid/base mode.

To connect acid or base solutions via the pumps and to the Cellbag bioreactor, follow the steps below.

Step	Action
1	If the acid and base pumps are not yet connected, see <i>Connecting acid/base pumps, on page 78</i> .
2	Connect power to the WAVEPOD II controller. Switch ON .
3	In the MAIN MENU screen, press pHOPT . <i>Result:</i> the pHOPT CONTROL screen opens. The control parameters are shown on the right hand side.
4	Select the desired pH control scheme.
5	Set pH setpoint pH SP . Press SET but do not start the pH reading until the bag is filled and its content has been equilibrated.
6	Make sure that the base pump direction is correct and turn on all switches on the pump.
7	Route the base tubing through the pump.
8	Connect, using aseptic technique, base tubing to the Cellbag bioreactor using either tube fusing equipment or a male luer/MPC connector.



NOTICE
Always use aseptic technique when connecting or disconnecting tubing to the Cellbag bioreactor.

9	Repeat steps 5 and 6 for the acid tubing if acid/base mode is selected.
---	---

Note: *It is recommended not to start the pH sensor and do the initial offset calibration until the bag content has been equilibrated at the desired temperature. pH control should not be started until a stable pH value can be measured and an offset calibration has been performed, that is, not until the temperature of the Cellbag content has equilibrated.*

Tip: *If the same port will be used for inoculation and acid or base addition, connect the acid or base after inoculation.*

Connect CO₂ to WAVEPOD II

Connect CO₂ if you are using CO₂/base mode. For connection of CO₂, see *Connect CO₂ or O₂ gas to WAVEPOD II*, on page 196.

Set pH control parameters

Parameters for pH control are set in the **pH CONTROL SETUP** screen, see *pH control setup screen*, on page 162. More information about the pH measurement and control is provided in *Section B.2 pH measurement and control*, on page 257.

The tables below show suggestions for pH cycle times, P and I values for some typical combinations of Cellbag bioreactor sizes and airflows. The settings should always be optimized for the current applications since the response of the pH adjustment is affected by for instance the fill volume and the buffer capacity of the cell culture media.

Note: *The D value is normally set to zero in pH control.*

Settings for pH control using CO₂

Cellbag size	Airflow (L/min)	Control cycle (s)	P	I
50 L	0.5	520	0.55	6000
	0.4	570	0.55	6500
	0.3	650	0.55	7500
	0.2	820	0.65	7500
	0.1	1000	0.75	8500

Cellbag size	Airflow (L/min)	Control cycle (s)	P	I
20 L	0.5	290	0.35	3500
	0.4	310	0.35	3800
	0.3	330	0.35	4100
	0.2	390	0.4	4500
	0.1	610	0.45	6000

Cellbag size	Airflow (L/min)	Control cycle (s)	P	I
10 L	0.5	260	0.3	2800
	0.4	270	0.3	3000
	0.3	290	0.3	3200
	0.2	320	0.35	3600
	0.1	430	0.4	5000

Cellbag size	Airflow (L/min)	Control cycle (s)	P	I
2 L	0.5	140	0.3	1600
	0.4	140	0.3	1650
	0.3	140	0.3	1700
	0.2	150	0.33	1800
	0.1	170	0.36	2200

Tip: A high airflow gives a faster control and vice versa. Using Cellbag 50L with a low air flow will result in a deflated Cellbag and very slow control. The higher the air flow the less amount of time spent in base control sub mode will be needed. However, an unnecessary high air flow will increase evaporation from the culture.

Settings for pH control using ACID/BASE

The values in the table below are based on the use of 0.5 M HCl and 0.5 M NaOH as acid/base.

Liquid volume (L)	Pump flow (mL/min)	Control cycle (s)	P	I
25	50	60	0.7	3000

Liquid volume (L)	Pump flow (mL/min)	Control cycle (s)	P	I
10	20	60	0.7	3000
5	10	60	0.7	3000
1	2	60	0.7	3000

Note: If using acid/base solutions with a molarity other than 0.5, compensate by changing the pump flow. For media with higher buffer capacity the pump flow may need to be increased. For media with low buffer capacity, the pump flow may be decreased. For instructions how to calibrate the pump flow, see Pump flow calibration, on page 193.

Deadband settings

In **CO₂/BASE** control mode, it is strongly recommended to use CO₂ deadband = 0. By setting a higher value, the accuracy of the CO₂ control is decreased. The best results are achieved when the deadband value is set to 0.

In **ACID/BASE** control mode, use deadband > 0. The deadband is given as a percentage of the control cycle and sets the shortest possible pump time. For example, if the deadband is set to 2.0% (which is the default value), the shortest pump time will be 0.02 × control cycle time. Shorter pump times will not be executed. If unnecessary toggling occurs between acid and base injections in **ACID/BASE** control mode, increase the deadband setting.

Pump flow calibration

The pump flow should be calibrated from WAVEPOD II as outlined below.

Step Action

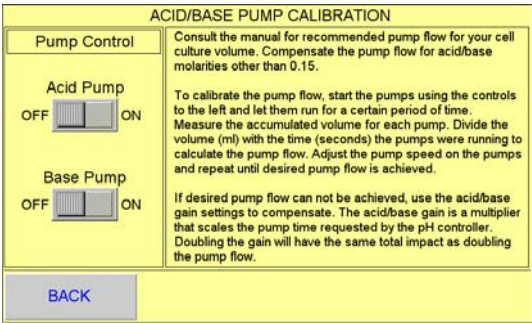
- 1 Ensure that pH control is turned off, see *pHOPT CONTROL* screen, on page 121.
- 2 Open the pH control setup screen, see *pH control setup* screen, on page 162.

pH CONTROL SETUP

DEV ALARM OFF ☐ ON ☐ DEV limit (pH) 0.10 Set control cycle times CO ₂ /BASE Transition Delay Pump Calibration	ACID/BASE DBAND (%) 2.0 P 0.70 I 3000 D 0 Acid gain 1.0 Base gain 1.0	CO₂ DBAND (pH) 0.00 P 0.35 I 4100 D 0 CO ₂ min 0.0 CO ₂ max 15.0
---	--	--

BACK Info/Help

- | Step | Action |
|------|---|
| 3 | Click the Pump Calibration button to open the Acid/base pump calibration screen. |



- | | |
|---|--|
| 4 | Using the controls on the Acid/base pump calibration screen, start the pump and run it for a set time, for example 60 s. |
| 5 | Calculate the actual pump flow per second, and adjust the pump speed as necessary. |

Note: If the desired pump flow cannot be achieved, the Acid or Base gain settings can be adjusted in the pH control setup screen to compensate, see below.

Gain

Gain is a multiplier that scales the controller output. The default value for gain is 1.0. Setting gain to 2.0 will double the pump time requested from the pH controller. Setting gain to 0.5 will half the requested pump time. A change in gain has the same total impact as a change in pump flow. It is recommended to first try to calibrate the pump flow, since a large gain may truncate the regulator output.

Prepare O2MIX or CO2MIX control

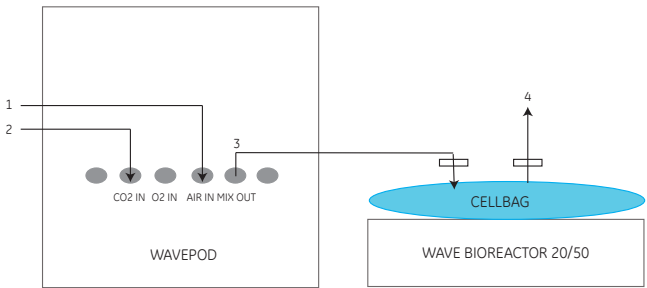
Introduction

The CO₂ module is used to inflate and ventilate the Cellbag disposable bioreactors with air containing a variable CO₂ concentration, while the O₂ module varies the O₂ concentration. Carbon dioxide and oxygen sensors inside WAVEPOD II measure and control the gas mixing. Air, CO₂ and O₂ are connected to WAVEPOD II and the enriched air is connected to the Cellbag bioreactor.

Note: Carbon dioxide and oxygen control require that CO2MIX and O2MIX, respectively, are part of the WAVEPOD II configuration.

Illustration of CO₂MIX control

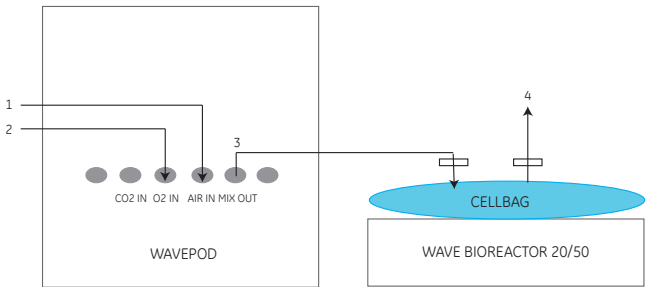
In this illustration, carbon dioxide gas is supplied to WAVEPOD II for CO₂MIX control.



Part	Function
1	Ambient air or process air
2	CO ₂ gas source
3	Air mixture to Cellbag
4	Expelled gas

Illustration of O₂MIX control

In this illustration, oxygen gas is supplied to WAVEPOD II for O₂MIX control.



Part	Function
1	Ambient air or process air
2	O ₂ gas source
3	Air mixture to Cellbag
4	Expelled gas

Connect air to WAVEPOD II

If WAVEPOD II is used for control of the oxygen or carbon dioxide concentration in the Cellbag headspace, air will be drawn in and mixed with the gas.

For...	Then...
ambient air intake	Leave the AIR IN port unconnected.
process air intake	Connect the AIR IN port to the process air source (< 0.2 bar or 2.9 psig).

Tip: *It is possible to produce an oxygen mixture with concentrations below 21% (air), by connecting nitrogen gas to the **AIR IN** port (< 0.2 bar or 2.9 psig). Note that this will make it necessary to set the O2 min limit in the DO control setup screen to a value less than the default value of 21.0%. DO control setup screen, on page 160.*



WARNING

If nitrogen is connected to the **AIR IN** there may be a leakage of nitrogen inside WAVEPOD II during normal use, even if there is no gas flow to the instrument. Make sure that the room is well ventilated and that the nitrogen is shut off when not needed.

Connect CO₂ or O₂ gas to WAVEPOD II

Follow the instruction below to connect CO₂ or O₂ enriched aeration to WAVEPOD II, when aeration is controlled from WAVEPOD II. This instruction also applies for when CO₂ is used for pH control.



CAUTION

When connecting gas to the equipment, ensure that the correct gas, gas quality and gas pressure are used to avoid hazards or undesired effects on the culture.



WARNING

To prevent any gas leakage from the stand-alone instrument CO2MIX20, always switch off the CO₂ supply when not used. During cultivation using CO2MIX20, make sure that the room is well ventilated.



WARNING

To prevent any gas leakage from the stand-alone instrument O2MIX20, always switch off the O₂ supply when not used. During cultivation using O2MIX20, make sure that the room is well ventilated.

Step	Action
1	Connect power to the WAVEPOD II controller. Switch ON . Allow 5 minutes for the instrument to warm up and stabilize.
2	Set the external gas source (CO ₂ or O ₂) to between 0.7 to 1.0 bar (10 to 15 psig). Connect the gas source to the CO₂ IN or O₂ IN inlet port on WAVEPOD II. WAVEPOD II is equipped with an internal pressure regulator requiring no user adjustment. Note: <i>A green indicator will be displayed on the CO₂ CONTROL/ O₂ CONTROL screen if the gas inlet pressure is sufficient for operation. A red indicator shows that the gas pressure is too low for proper control.</i>
3	Leave the AIR IN port on WAVEPOD II unconnected if you wish to mix in ambient air with the gas stream. Alternatively, process air can be connected. Process gas pressure must be regulated to between 0.1 and 0.2 bar (1 to 3 psig).



NOTICE

The aeration control does not need to be turned on yet.
The CO₂, O₂ and/or pH controls do not need to be turned on until just before the cultivation is started.

Connect enriched air to WAVE

The gas/air mixture is pumped out from the **MIX OUT** port on WAVEPOD II. Connect this directly to the Cellbag inlet filter.



NOTICE

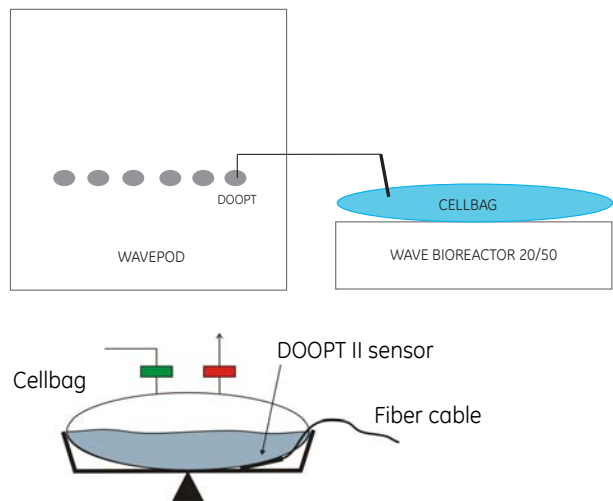
The CO₂MIX or O₂MIX control does not need to be turned on until just before the cultivation is started.

Prepare DO control

Note: DO control requires that DOOPT II is part of the WAVEPOD II configuration.

Illustration of DO control

The illustrations below show an overview of the connections for DO control.



Connect DOOPT II sensor and set parameters

The distal end of the optical fiber cable associated with the DOOPT II sensor should already be connected to the Cellbag bioreactor, see *Connect the optical fiber to the Cellbag bioreactor, on page 181*.

Step	Action
1	Turn on the power to the instrument.
2	Connect an optical fiber cable to the DOOPT port on the WAVEPOD II front.

Regarding initial calibration of the pHOPT sensor, see *Offset pHOPT calibration, on page 208*.

Connect O₂ to WAVEPOD II

Connect O₂ if you are using O₂ for DO control, see *Connect CO₂ or O₂ gas to WAVEPOD II, on page 196*.

Set DO control parameters

Parameters for DO control are set in the **DO CONTROL SETUP** screen, see *DO control setup screen, on page 160*. More information about dissolved oxygen measurement and control is provided in *Section B.3 DO measurement and control, on page 261*.

The tables below show what cycle times, P values and I values to use for DO control at various flow rates. The listed values are recommendations. The settings should always be optimized for the current application.

Note: The D value is normally set to zero in DO control. The deadband value for O₂ control can also normally be set to zero.

Settings for DO control using O₂

Cellbag size	Airflow (L/min)	Control cycle (s)	P	I
50 L	0.5	300	0.3	2000
	0.4	360	0.3	2500
	0.3	450	0.3	2800
	0.2	650	0.4	3300
	0.1	1000	0.5	3300

Cellbag size	Airflow (L/min)	Control cycle (s)	P	I
20 L	0.5	140	0.2	1500
	0.4	160	0.2	1650
	0.3	200	0.2	1800
	0.2	270	0.25	2200
	0.1	510	0.3	3500

Cellbag size	Airflow (L/min)	Control cycle (s)	P	I
10 L	0.5	100	0.15	900
	0.4	110	0.15	1000
	0.3	130	0.15	1100
	0.2	160	0.2	1400
	0.1	270	0.25	2200

8 Operation

8.5 Prepare WAVEPOD II

Cellbag size	Airflow (L/min)	Control cycle (s)	P	I
2 L	0.5	38	0.15	400
	0.4	42	0.15	440
	0.3	45	0.15	490
	0.2	53	0.17	580
	0.1	76	0.17	800

8.6 Set operation control and monitoring conditions

Set operating conditions

Set control and monitoring of parameters for rocking, temperature and aeration and optionally (depending on system configuration) for pH, dissolved oxygen, CO₂ and O₂. The WAVE Bioreactor instrument control system is described in *Chapter 5 WAVE Bioreactor control system, on page 83*. If optional stand-alone instruments are used for control and monitoring of parameters, the WAVEPOD II control system is described in *Chapter 6 WAVEPOD II Control system, on page 115* and control systems of WAVE stand-alone instruments are described in *Stand-alone instruments for WAVE Bioreactor 2/10 and 20/50 Operating Instructions*.

Recommendations on operating conditions

Each cell line and medium requires optimization of operating conditions. Typical rocking and aerating rates are shown in the table below.

Culture volume (liter)	Cellbag size (liter)	Rocking rate (rpm)	Aeration rate (lpm)
0.1	2	10	0.1
1	2	15	0.1
0.5 to 1	10	15	0.1
5	10	15 to 20	0.1 to 0.2
10	20 or 22	20 to 25	0.2
25	50	20 to 25	0.2 to 0.3

Rocking rate recommendations

Follow the recommendations listed below to optimize the rocking rate.

- The rocking rate should be set at the minimum rate that provides mixing and oxygen transfer without excessive foaming.
- If no wave is visible in the Cellbag bioreactor, increase the rocking rate.
- If there is excessive foaming, reduce the rocking rate.

8 Operation

8.6 Set operation control and monitoring conditions

- Cell concentration and oxygen uptake rate determine the necessary rocking rate for oxygen transfer.
 - The best way to determine the required rocking rate is to measure dissolved oxygen. This can be done by off-line or on-line measurement using DOOPT.
-

Rock angle recommendations

- The typical rock angle is 6 to 8 degrees.
 - For cells with high oxygen demand, the rock angle can be increased to 10 degrees.
 - For very foamy media, the rock angle should be reduced.
-

Aeration rate recommendations

The aeration rate (through the inlet air filter) has little effect on oxygen transfer. Aeration rates should be kept to a minimum to reduce evaporation, however too low aeration rates will lead to insufficient inflation of the Cellbag bioreactor and slow control with using CO₂ and O₂ gas.

Recommendations to reduce foaming

Follow the recommendations listed below to reduce foaming in the Cellbag bioreactor.

- For very foamy media, the rock angle should be reduced.
 - If extensive amounts of foam are generated, reduce the rocking speed. Note however that a sufficient rocking speed is critical for generation of a visible surface wave.
 - Excessive foaming occurs if the Cellbag bioreactor is not rigidly inflated. Check that you have sufficient airflow and that the pressure relief valve is functioning.
 - Add anti-foam reagent to the culture medium.
-

General recommendations

It is common practice to add 1 g/liter of pluronic F-68 to the culture medium as a shear protectant. Many commercial cell culture media already contains pluronic.



NOTICE

It is strongly recommended that Cellbag bioreactors with built-in optical sensors are covered with a non-transparent cover, such as the optional lid or the black bag in which the Cellbag bioreactor is delivered, during cultivation, to reduce sensor aging due to light exposure.

8.7 Procedures before inoculation

Introduction

This section provides descriptions of procedures. The touch screen commands are not provided.

For instructions to monitor and set operating conditions for the current system configuration, see relevant parts of *Chapter 5 WAVE Bioreactor control system, on page 83*.

The WAVEPOD II control system is described in *Chapter 6 WAVEPOD II Control system, on page 115* and control systems of WAVE stand-alone instruments are described in *Stand-alone instruments for WAVE Bioreactor 2/10 and 20/50 Operating Instructions*.

Verify system preparation

Follow the instruction below to prepare the system before filling the Cellbag bioreactor.

Step	Action
1	For Cellbag configured with optical sensors, make sure that the fiber cables are firmly attached to the Cellbag bioreactor and that the calibration values are entered via the pHOPT/DOOPT CONTROL screen. If using both pHOPT and DOOPT, make sure that the fiber cables are not interchanged by mistake.
2	Cover Cellbag to protect the optical sensors from excessive light.
3	Start rocking and aeration, see <i>Section 6.3 WAVEPOD II Parameter controls, on page 120</i> or <i>Section 5.2 Parameter controls, on page 87</i> .
4	Verify that the Rocker tray is firmly latched on the Rocking plate.
5	Verify that the Cellbag bioreactor is firmly inflated and secured to the Rocker tray. The Cellbag bioreactor should be taut but not creased. This is important in order to reduce foaming and decrease the risk for liquid in the outlet filter flow path.
6	Verify that air is released through the outlet pressure relief vent by pressing down gently on the bag with one hand and sensing a release of air through the outlet pressure relief valve with the other hand. Note that this may cause a temporary over-pressure alarm on WAVEPOD II.

Fill Cellbag with medium



WARNING

Heavy object. Filled Cellbag bioreactor have a considerable weight and heavy lifts must be done with care. Use 1 person per multiple of 15 kg weight, for example 3 persons for 30 to 45 kg. All lifting and moving must be performed in accordance with local regulations.

Follow the instruction below to fill the Cellbag bioreactor with culture medium.

Step	Action
------	--------

- | | |
|---|--|
| 1 | Stop the rocking. |
| 2 | Reduce the airflow to avoid high pressure alarm. |

Note:

Continue airflow to the headspace to keep the Cellbag bioreactor inflated. This is important to avoid excessive foaming.

- | | |
|---|---|
| 3 | Connect, using aseptic technique, tubing from the medium container to the Cellbag bioreactor using either the inlet tubing with tube fusing equipment, or by connecting a male luer or MPC fitting to one of the luer ports or MPC ports, respectively. |
|---|---|



NOTICE

Always use aseptic technique when connecting or disconnecting tubing to the Cellbag bioreactor.

Note:

It is recommended to move the Cellbag bioreactor into a biosafety cabinet. Clamp off all open tubing before moving the bag to prevent leakage.

- | | |
|---|--|
| 4 | Reset the tare weight as described in <i>Section 5.2.2 Weight control, on page 89</i> . |
| 5 | Transfer the desired volume of medium into the Cellbag bioreactor using a pump, gravity flow or an increased pressure. |

Step	Action
6	Increase the airflow to operation values.  CAUTION To avoid excessive stress on the Cellbag bioreactor creases, do not start rocking before the Cellbag bioreactor is completely inflated.
7	When the Cellbag bioreactor is completely inflated, restart the rocking.
8	If required, adjust the rocking speed by changing the set point value. • Increase the rocking speed if no wave is visible. • Reduce the rocking speed if there is excessive foaming. • For rocking speed recommendations, see <i>Recommendations on operating conditions</i>, on page 201.

Equilibrate the culture medium

During equilibration, the medium reaches the operating temperature and pH, the Cellbag bioreactor reaches the correct pressure and gas composition, and the carbon dioxide concentration in the head space and the medium is equilibrated. This takes several hours.

- Note:** *A stable and reliable pH and/or DO value will not be displayed until the temperature of the Cellbag content has equilibrated.*
- Note:** *The standard pHOPT Cellbag bioreactors are calibrated for measurement at 37°C. A reduced accuracy can be expected if measuring at temperatures other than the calibration temperature.*
- Similarly, the standard DOOPT II Cellbag bioreactors are calibrated at an atmospheric pressure stated on the DOOPT II label ("calp"). Since the atmospheric pressure is likely to deviate from "calp" during the cultivation this will cause a deviation in the DO measurement. The difference is approximately 1% air sat/10 mbar.*

Follow the instruction below to equilibrate the culture medium.

Step	Action
1	Start rocking at the desired rocking speed and angle.
2	Start aeration at the desired airflow. Use appropriate CO ₂ mixture, if any, for the cultivation.

Step	Action
3	Start temperature control at the appropriate temperature.
4	Leave the WAVE Bioreactor system until the culture medium has equilibrated.
5	Make sure that the key culture parameters pH, DO and temperature are stable before inoculation.
6	Adjust the rocking speed and rocking angle, if necessary, to optimize the wave. See <i>Section 8.6 Set operation control and monitoring conditions, on page 201</i> .



NOTICE

It is strongly recommended that Cellbag bioreactors with built-in optical sensors are covered with a non-transparent cover, such as the optional lid or the black bag in which the Cellbag bioreactor is delivered, during cultivation, to reduce sensor aging due to light exposure.



NOTICE

Gas bubbles on the optical pHOPT and DOOPT II sensors may cause incorrect measurement (pH) and reduced gas control efficiency (pH, DO).

Gas bubbles may form at the bottom of the Cellbag bioreactor during filling and equilibration, especially if the medium is filled at a low temperature and low rocking rates.

Check the sensors for gas bubbles at equilibrium and remove any bubbles from the sensors by flicking the sensors on the underside of the Cellbag bioreactor.



WARNING

To prevent any gas leakage from the stand-alone instrument CO2MIX20, always switch off the CO₂ supply when not used. During cultivation using CO2MIX20, make sure that the room is well ventilated.



WARNING

To prevent any gas leakage from the stand-alone instrument O2MIX20, always switch off the O₂ supply when not used. During cultivation using O2MIX20, make sure that the room is well ventilated.

Initial pH calibration

When a new Cellbag has been installed and filled, and its content has been equilibrated, the initial calibration values for the pHOPT sensor shall be entered.

Step	Action
1	Press pHOPT in the MAIN MENU .
2	Press CALIB in the pHOPT CONTROL screen.
3	Enter the five calibration values of the Cellbag pHOPT label in the pH SENSOR PARAMETERS pop-up screen and press SET .

Offset pHOPT calibration

Offset calibrate the pHOPT sensor prior to cultivation and then whenever necessary using an external pH meter according to the instruction below.

Step	Action
1	Turn on the power to the instrument.
2	Make sure that the pH optical fiber cable is connected both to WAVEPOD II and to Cellbag.
3	Make sure that the Cellbag bioreactor is filled with equilibrated media.
4	Measure the pH by sampling Cellbag and using an external calibrated pH meter.
5	Press pHOPT in the MAIN MENU screen.
6	Press OFFSET in the pHOPT CONTROL screen.
7	Enter the measured value in the OFFSET CALIBRATION pop-up screen and press SET .

Step	Action
8	Press BACK. Performing an offset calibration will change the cpH0 value in the pH SENSOR PARAMETERS pop-up window.

DO calibration

Initial DO calibration

When a new Cellbag bioreactor has been installed and filled, and its content has been equilibrated, the initial calibration values for the DOOPT II sensor shall be entered.

Step	Action
1	Press DOOPT CONTROL in the MAIN MENU .
2	Press CALIB in the DOOPT screen.
3	Enter the five calibration values of the Cellbag DOOPT II label in the DO SENSOR PARAMETERS pop-up screen and press SET .

DO calibration (offset)

To correct for variations in conditions for the actual culture, the DOOPT II sensor can be offset calibrated at 0% and 100% air saturation.

The need for this should be decided from case to case.

Zero oxygen offset calibration



WARNING

If nitrogen is connected to the **AIR IN** there may be a leakage of nitrogen inside WAVEPOD II during normal use, even if there is no gas flow to the instrument. Make sure that the room is well ventilated and that the nitrogen is shut off when not needed.

Follow the instruction below to perform a zero oxygen calibration using WAVEPOD II. Prepare the Cellbag bioreactor by filling it with medium, see *Fill Cellbag with medium*, on page 205.

8 Operation

8.7 Procedures before inoculation

Step	Action
1	Connect 100% N₂ to the AIR IN inlet (< 0.2 bar or 2.9 psig). Start rocking at a moderate rocking rate and angle, for example, 25 rpm and 8°. Other settings may be used to adjust the time to reach stable conditions before the offset calibration.
2	Allow the medium to equilibrate at the cultivation temperature. Check the sensor for gas bubbles. If there are bubbles on the sensor surface remove them by tapping the bag port from the underside.
3	Open the DOOPT CONTROL menu. Press the CALIB button to open the DO SENSOR PARAMETERS pop-up window. Make sure that the DOOPT calibration values according to the Cellbag label have been entered correctly (see Connect DOOPT II sensor and set parameters). Note: <i>If an offset calibration at 100% has already been performed, the calibration values will differ from the label.</i> Return to the DOOPT CONTROL menu.
4	Press Comp temp to either select the automatic temperature reading or to enter the ambient temperature manually.
5	Wait until the DO reading is stable at its lowest level.
6	Press the OFFSET button. In the pop-up window, press the SET 0% button. Return to the DOOPT CONTROL menu using the BACK button. The N₂ gas may now be removed from the AIR IN inlet.
7	The 0% offset calibration will change the clzp and clzt values in the DO SENSOR PARAMETERS pop-up window. A message will appear in this window to indicate that a change has been made.

100% air saturation offset calibration

Follow the instruction below to perform a 100% air saturation calibration using WAVEPOD II.

Prepare the Cellbag bioreactor by filling it with medium, see *Fill Cellbag with medium*, on page 205.

Step	Action
1	Use air at the AIR IN inlet. Make sure that the CO₂ and O₂ controls are shut off. Start rocking at a moderate rocking rate and angle, for example, 25 rpm and 8°. Other settings may be used to adjust the time to reach stable conditions before the offset calibration.
2	Allow the medium to equilibrate at the cultivation temperature. Check the sensor for gas bubbles. If there are bubbles on the sensor surface remove them by tapping the bag port from the underside.
3	Open the DOOPT CONTROL menu. Press the CALIB button to open the DO SENSOR PARAMETERS pop-up window. Make sure that the DOOPT calibration values according to the Cellbag label have been entered correctly (see Connect DOOPT II sensor and set parameters). Note: <i>If an offset calibration at 100% has already been performed, the calibration values will differ from the label.</i> Return to the DOOPT CONTROL menu.
4	Press TCOMP to either select the automatic temperature reading or to enter the ambient temperature manually.
5	Wait until the DO reading is stable.
6	Press the OFFSET button. In the pop-up window, press the SET 100% button. Return to the DOOPT CONTROL menu using the BACK button.
7	The 100% offset calibration will change the clhp and clht values in the DO SENSOR PARAMETERS pop-up window. A message will appear in this window to indicate that a change has been made.

8.8 Perform cultivation

Introduction

This section describes the basics of performing a cultivation. After inoculation, the set desired operation conditions are applied and the cultivation started. During the cultivation, key parameters are monitored and the settings can be adjusted.

Inoculate the Cellbag bioreactor

Follow the instruction below to inoculate the Cellbag bioreactor aseptically.

Step	Action
1	Stop the rocking motion. Note: <i>Continue airflow to the headspace to keep Cellbag inflated.</i>
2	Make sure that the tubing connected to the inoculum container is clamped.
3	Connect, using aseptic technique, tubing from the inoculum container to the inlet tubing using either tube fusing equipment or a ReadyMate connector.  NOTICE Always use aseptic technique when connecting or disconnecting tubing to the Cellbag bioreactor.
4	Unclamp the inlet tubing and inoculum container tubing.
5	Transfer the desired volume of inoculum into the bag using a pump, gravity flow or increased pressure.
6	Restart the rocking motion.

Note: *Ensure that the Cellbag bioreactor does not become overpressurized when filling with inoculum.*

Start the cultivation

Follow the instruction below to start the cultivation.

Step	Action
1	Make sure that desired operating conditions, mainly rocking rate, rocking angle, aeration, and temperature, are set. For some system configurations it is also possible to control dissolved oxygen, pH, CO₂ concentration, O₂ concentration and perfusion parameters. The setpoint values are entered in the respective control screens that are reached from the main screen of WAVE Bioreactor 20/50 or WAVEPOD II. See <i>Recommendations on operating conditions</i>, on page 201 and <i>Chapter 5 WAVE Bioreactor control system</i>, on page 83 for further information.
2	Start rocking, aeration and other, as applicable, monitor and/or control functions in their respective control screens.
3	To start monitoring cultivation with UNICORN DAQ 1.0, follow the instructions given in <i>Quick start guide</i>, on page 170.

- Note:**
- Aeration is required for CO₂ and O₂ control.
 - CO₂ control is required for pH control using CO₂ and base.
 - O₂ control is required for DO control using O₂.

- Note:** Issues with the systems or set cultivation conditions are acknowledged by alarms. Alarm indication depends on system configuration and if the cultivation is controlled from the WAVE Bioreactor 20/50 instrument or from WAVEPOD II.
- On the WAVE Bioreactor 20/50 instrument a new alarm is indicated by a flashing **ALARM** button in the main screen of the Touch screen, see Chapter 5 WAVE Bioreactor control system, on page 83 for handling Alarms.
 - On WAVEPOD II a new alarm is indicated by a flashing **ALARMS** button in the main screen of the Touch screen, see Chapter 6 WAVEPOD II Control system, on page 115 for handling Alarms.



NOTICE

It is strongly recommended that Cellbag bioreactors with built-in optical sensors are covered with a non-transparent cover, such as the optional lid or the black bag in which the Cellbag bioreactor is delivered, during cultivation, to reduce sensor aging due to light exposure.

Monitor cultivation parameters

Note: *Make sure that the Cellbag bioreactor is rigidly inflated at all times when rocking. Using an underinflated bag will increase the risk for cracks and leakage. The Cellbag upper surface should be drum-tight.*

It is possible to monitor rocking rate, rocking angle, aeration, and temperature on the WAVE Bioreactor or WAVEPOD II touch screens. The main screens provides current data, while data logging is provided on the trend screens reached from the parameter details screens.

For some system configurations it is also possible to monitor and/or control dissolved oxygen, pH, CO₂ concentration, O₂ concentration and perfusion parameters. For system configurations without on-line control, samples may be taken for external measurement, see *Sample the Cellbag bioreactor, on page 216*.

UNICORN DAQ 1.0 is an optional software, which provides data acquisition with logging during the entire cultivation and evaluation of the data after the cultivation. For information about monitoring data parameters using UNICORN DAQ, see below.

Monitor cultivation using UNICORN DAQ 1.0

The UNICORN DAQ module **System control** provides tools for viewing a cultivation. The entire cultivation is logged.

See *Chapter 7 UNICORN DAQ 1.0 software, on page 166* for information about how to:

- start data accusation
- change view details (zoom in on a curve, change y axis unit, select curves to display etc.)
- view logged information (alarms etc.)
- stop data acquisition

For complete information about UNICORN DAQ 1.0, see the UNICORN DAQ 1.0 - User manual for WAVE Bioreactor.

When UNICORN DAQ is used, make sure that the **pH WAVEPOD** configuration is selected to log pH readings (**UNICORN Manager:System Setup:Components**). For trouble shooting purpose it is strongly recommended to also select **pH Details** to log LED, amplitude and phase angle.

Adjust settings during the cultivation

Change settings for rocking rate and rocking angle via **ROCKER** in the main screen or the WAVE Bioreactor instrument button on the WAVEPOD II **MAIN MENU** screen, if necessary.

Further instructions for adjusting settings are found in *Chapter 5 WAVE Bioreactor control system, on page 83* and *Chapter 6 WAVEPOD II Control system, on page 115*. Refer to the recommendations in *Section 8.6 Set operation control and monitoring conditions, on page 201*.

If desired, other monitor and/or control functions can also be adjusted.

8.9 Cultivation options

Calibrate sensors

When necessary, offset calibrate the pHOPT as described in *Offset pHOPT calibration*, on page 208.

Tip: For the most accurate pH control it is recommended to check the pH daily and do an offset calibration when the difference between the read pH value and the off-line reference value is more than pH 0.05.

Note: The DOOPT II sensor should only be offset calibrated before inoculation.

Sample the Cellbag bioreactor

Samples may be taken several times using the same sampling connector without any danger of compromising sterility. The risk for aerosols is low.

Follow the instruction below to sample the Cellbag bioreactor.

Step	Action
1	Stop the rocking.
2	Remove the cap from the blue sampling connector (see Section 3.3 Cellbag bioreactor, on page 42 for a Cellbag description).
3	Wipe the top of the sampling connector with 70% alcohol (or equivalent).



Step	Action
4	Using aseptic technique, attach a sterile disposable syringe with luer connector onto the sampling connector. 
5	Release the tubing clamp and withdraw a sample into the syringe. You may need to push down on the Cellbag bioreactor to force the liquid up the sample tube.
6	Remove the syringe and wipe the top of the sampling connector again with 70% ethanol and replace the cap.
7	Pinch the sampling connector tubing a few times to ensure that any liquid in the tubing drains back into the Cellbag bioreactor.
8	Close the tubing clamp.
Note:	<i>A standard syringe or luer connector is used without a needle.</i>
Note:	<i>The sampling connector has a fairly small orifice. If you are working with large microcarriers or large cell aggregates, do not use the sampling connector.</i>

Scaling up cultivation

Cellbag bioreactors have a large range in operating volume. This allows efficient scaleup and eliminates tedious sequential transfers. Start at low volume and add fresh medium to the Cellbag bioreactor as the cells grow. Up to a 1:10 expansion is possible in a single bag.

A typical inoculum sequence is:

Step	Action
1	Start with 200 mL medium in a 2 L Cellbag. Add inoculum.
2	When cells reach 2×10^6 to 3×10^6 cells/mL, add 300 mL medium to the Cellbag bioreactor.

Step	Action
3	When cells again reach 2×10^6 to 3×10^6 cells/mL, add more medium to bring the volume to 1 liter.
4	When these cells reach 2×10^6 cells/mL, transfer using a tube-fuser to a Cellbag 20L containing 2 liters of medium.
5	When the cells in the 20 L Cellbag again reach 2×10^6 cells/mL, bring the volume to 10 liters and continue cultivation at full volume.

In this sequence, only one transfer was made in going from 200 mL to 10 L of culture. This saves time and reduces the risk of contamination. This scheme can also be used to scale-up inoculum for larger conventional bioreactors.

Culture medium exchange

For instructions to monitor and set operating conditions for the current system configuration, see relevant parts of *Chapter 5 WAVE Bioreactor control system, on page 83*. For a description of the culture bag components, see *Section 3.3 Cellbag bioreactor, on page 42*.

Note: *To avoid possible oxygen depletion, the culture medium exchange operation should be performed in less than one hour.*

Step	Action
1	Stop the rocking and aeration and clamp off the inlet and outlet filters.
2	Remove the Rocker tray from the WAVE Bioreactor instrument and place it in the vertical position resting against a support. Allow particulates (including cells and microcarriers, if applicable) 10 to 15 minutes to settle.
3	Connect tubing to the harvest line on the Cellbag bioreactor. The other end of this tubing should be connected to a sterile collection vessel.
4	Using a peristaltic pump or gravity flow, remove the desired amount of supernatant culture liquid by manually manipulating the flexible wall of the Cellbag bioreactor.
5	Disconnect the tubing and reconnect to fresh medium to refill the Cellbag bioreactor.
6	Place the Rocker tray back on the WAVE Bioreactor instrument.
7	Open the inlet and outlet filter clamps and restart aeration and rocking.

Perfusion culture

During perfusion culture cell-free harvest is withdrawn and fresh medium is added continuously or shot-wise.

Requirements:

- Cellbag bioreactors with internal perfusion filter or connected to external retention filters
- Harvest and feed pumps (PUMP20 or external)
- BASE20/50EHT configuration

Contact a GE Healthcare application specialist for advice on setting up perfusion culture.

For instructions to set perfusion culture operating conditions for the current system configuration, see relevant parts of *Chapter 5 WAVE Bioreactor control system*, on page 83 for control system instructions.

8.10 End cultivation



WARNING

To prevent any gas leakage from the stand-alone instrument CO2MIX20, always switch off the CO₂ supply when not used. During cultivation using CO2MIX20, make sure that the room is well ventilated.



WARNING

To prevent any gas leakage from the stand-alone instrument O2MIX20, always switch off the O₂ supply when not used. During cultivation using O2MIX20, make sure that the room is well ventilated.



WARNING

If nitrogen is connected to the **AIR IN** there may be a leakage of nitrogen inside WAVEPOD II during normal use, even if there is no gas flow to the instrument. Make sure that the room is well ventilated and that the nitrogen is shut off when not needed.

Stop cultivation and harvest

Follow the instruction below to stop cultivation and harvest.

Tip: *Harvest can also be performed by using gravity flow while manually manipulating the flexible wall of the Cellbag bioreactor. An air flow through the Cellbag bioreactor may be applied to give a pressure that facilitates the emptying.*

Step	Action
1	Stop the rocking, aeration and other control and monitoring systems.
2	Stop the data logging in UNICORN DAQ, if used: • Click End in the System Control module • Confirm and save the result file by clicking OK in the confirmation dialog
3	Connect a harvest pump connector to the HARVEST PUMP port on the WAVE Bioreactor instrument rear panel.

Step	Action
4	Route the harvest tubing from the harvest container through the pump and connect to the harvest port on the Cellbag bioreactor. (See Section 3.3 Cellbag bioreactor, on page 42 for a Cellbag description.)
5	Empty the content of the Cellbag bioreactor for further processing using the harvest pump. - Press the WEIGHT button in the WAVE Bioreactor main screen. <i>Result:</i> The WEIGHT screen opens, see Section 5.2.2 Weight control, on page 89. - Press SP box and enter the net weight setpoint value corresponding to an empty bag. - Start the harvest pump by pressing the ON button below HARV. <i>Result:</i> The button changes to OFF and the indicator Harvesting appears. The harvest pump runs until the net weight is below the setpoint. Note: <i>The harvest pump does not turn on if the net weight is less than the low alarm limit.</i> Note: <i>This procedure requires that a loadcell is installed. A harvest pump can also be managed separately without the WAVE Bioreactor control system.</i>
6	Clamp off the inlet and outlet filters of the Cellbag bioreactor.
7	Disconnect the air inlet tube of the Cellbag bioreactor.
8	Disconnect any other tubes and sensors still connected to the Cellbag bioreactor.
9	Remove the empty Cellbag bioreactor from the instrument: - Open the guides on the Rocker tray by lifting the cam levers located on either side of the Rocker tray. - Release the bag from the Rocker tray. - Remove the bag from the Rocker tray.
Tip:	<i>The WAVE Bioreactor system has minimal turnaround time. Simply remove the empty Cellbag and install a new one on the instrument.</i>

Procedures after cultivation
completion

After completing a run and the removal of the Cellbag bioreactor, follow the instruction below.

Step	Action
1	Turn off (O) the power switches of all used instrument. Power switches are generally located at the rear of respective instrument.
2	Close all gas supplies at the source to prevent gas leakage during down time.
3	If required clean system components. For cleaning instructions, see <i>Section 9.3 Cleaning the instrument, on page 227</i> .

9 Maintenance

About this chapter

This chapter describes how to perform maintenance of WAVE Bioreactor 20/50 and WAVEPOD II.

In this chapter

Section	See page
9.1 General information	224
9.2 Maintenance program	225
9.3 Cleaning the instrument	227
9.4 Safety switch inspection procedure	228
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9.6 Temperature adjustment	231
9.7 Maintenance of WAVEPOD II	234

9.1 General information



WARNING

Electrical shock hazard. All repairs should be done by service personnel authorized by GE Healthcare. Do not open any covers or replace parts unless specifically stated in the user documentation.



WARNING

Disconnect power. Always disconnect power from the instrument before performing any work or maintenance task on the instrument.

Maintenance of stand-alone instruments

For information on maintenance of stand-alone instruments, refer to *Stand-alone instruments for WAVE Bioreactor 2/10 and 20/50 Operating Instructions*.

9.2 Maintenance program

Introduction

This section lists the periodic maintenance activities that should be performed by the user of a WAVE Bioreactor system, as well as maintenance activities that should be performed when required.

The maintenance is divided into:

- Before each cultivation
- After each cultivation
- Annual maintenance
- Bi-annual maintenance
- Maintenance when required

Periodic maintenance program

The following periodic maintenance should be performed by the user of WAVE Bioreactor.

Interval	Maintenance action	See section
Before each cultivation	pHOPT sensor calibration	<i>Section 9.5 Calibration, on page 230</i>
Before each cultivation	DOOPT II sensor calibration	<i>Section 9.5 Calibration, on page 230</i>
After each cultivation	Instrument surface cleaning	<i>Section 9.3 Cleaning the instrument, on page 227</i>
Weekly	Safety switch inspection	<i>Section 9.4 Safety switch inspection procedure, on page 228</i>

Maintenance when required

The following maintenance should be performed by the user of WAVE Bioreactor when required.

Maintenance action	See section
Clean the instrument externally	<i>Section 9.3 Cleaning the instrument, on page 227</i>

Maintenance action	See section
Adjustments of temperature	<i>Section 9.6 Temperature adjustment, on page 231</i>
Reset circuit breakers or replace fuses	<i>Replacement of fuses, on page 234</i>

Maintenance performed by GE
Healthcare service

Interval	Maintenance action
When required	Adjustments of controls ¹
6000 hr operation or annually	Preventive maintenance

¹ Angle, speed, aeration, load cells, CO₂, O₂, temperature.

9.3 Cleaning the instrument

General

The instrument must be turned off and unplugged before cleaning begins.



CAUTION

Water should not be applied directly to the instrument.



CAUTION

Do not connect power to the instrument until it is completely dry.

Instruction

Clean the exterior of the instrument with a damp cloth with water and, if required, alcohol.
Do not use abrasive cleaners.

9.4 Safety switch inspection procedure

Required materials

3/8" ID x 5/8" OD, C-Flex or similar type tubing, 300 mm (12") long.

Instruction

Inspect the safety switches according to the instruction below:

Step	Action
1	Turn on the power to the instrument.
2	Turn on the rocking: • Set the instrument rocking speed to 10 rpm, • set the angle to 12 degrees, • press ROCK button to start rocking.
3	While the instrument is rocking, place one end of the 300 mm long piece of 5/8 inch (OD) tubing between the safety switch and the rocking platform at the front of the instrument.



Result: The instrument should lightly squeeze the tubing, return to level and then stop rocking. Within 30 seconds the background lighting of the Touch screen should turn red and flash. The following message should be displayed: **"SAFETY BUMPER SWITCH HIT" "CYCLE POWER TO RESET"**.

Step	Action
4	Cycle the power: • Turn off the instrument • Turn on the instrument
5	Repeat the procedure testing for the rear safety switch.
Note:	<i>If the instrument reacts differently than described, stop the inspection and contact Technical support. Do not use the equipment as the safety switches may not be working properly.</i>

9.5 Calibration

Maintenance interval

Before using pH control, the pHOPT sensor calibration values specific for the current Cellbag must be entered. Before starting cultivation and whenever necessary during cultivation offset calibration of the pHOPT sensor should be performed.

Similarly, before using DO control, the DOOPT II sensor calibration values specific for the current Cellbag must be entered. Before starting cultivation offset calibration of the DOOPT II sensor should be performed.

pH calibration

For...	see...
setting pHOPT sensor parameters	<i>Section 8.5 Prepare WAVEPOD II, on page 188.</i>
offset calibration for pHOPT	<i>Section 8.7 Procedures before inoculation, on page 204.</i>

DO calibration

Calibration of the DOOPT II sensor is described in *DO calibration, on page 209.*

9.6 Temperature adjustment

Introduction

The SRTDX temperature sensor is a PT100 platinum resistance detector that must be calibrated to the electronics within WAVE Bioreactor 20/50 to ensure peak performance. If a sensor is moved to a different WAVE Bioreactor, or if the temperature reading is found not to be reliable then the sensor must be recalibrated as described here.

Required materials

- Service Cellbag bioreactor
Note: *Service Cellbag bioreactors are not sterile and are not to be used for cell culture.*
 - Temperature standard
 - RTD Temperature probe 1/8" (0.32 cm) diameter with stem length > 16 cm, accuracy of 0.1°C or better
 - PTFE tape
 - 1 to 5 liters of water, depending on the Cellbag bioreactor size
 - WAVE Bioreactor 20/50 with either KIT20 or KIT50 installed
-

Choice of calibration temperature

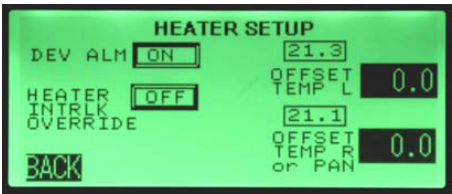
The temperature sensor has been shown to provide excellent linearity of response in the range 20–45°C, which is adequate for most cultivations. A single-point calibration is therefore normally sufficient. The calibration temperature should be chosen to mimic that of a culture. The following procedure uses a calibration temperature of 37.0°C.

Procedure

Follow the procedure below to calibrate the temperature sensor.

Step	Action
1	Install the Service Cellbag bioreactor on the tray and connect air lines and filter heaters as for a normal run as described in <i>Chapter 8 Operation, on page 174</i> .

Step	Action
2	Fill Cellbag bioreactor with at least 1 L water.
3	Wrap PTFE tape around the temperature standard probe and insert it into the temperature port of the Service Cellbag bioreactor. The PTFE tape should be wrapped enough to prevent Cellbag bioreactor leaking water or air. Ensure that the tip of the probe is immersed in the water.
4	Turn WAVE Bioreactor on, enable the aeration pump and allow time for Cellbag bioreactor to fill with air.
5	Set the target temperature to 37.0°C and enable the heater(s).
6	Allow the temperature to rise and settle at the target temperature, until the temperature reading no longer changes. This may take at least one hour.
7	Enter the SETUP screen of WAVE Bioreactor as described in <i>Enter the settings screen, on page 105</i> , and press the HEATER button. <i>Result:</i> The HEATER setup screen opens.



- 8 Compare the readings from the WAVE Bioreactor touch screen to the reading on the temperature standard. If the reading is less than $\pm 0.2^{\circ}\text{C}$ then the temperature sensor is calibrated within the tolerance limits and no further action need be taken.
- 9 If the temperature shown differs from the reading by more than 0.2°C then an offset value can be entered to calibrate the temperature sensor. The offset to be entered is the difference between the standard and the touch screen display. Use negative values if the standard shows a lower temperature than the touch screen.
- Example:* If the touch screen shows 37.0°C and the standard 37.5°C then the offset to be entered will be 0.5. If the touch screen shows 37.0°C and the standard 36.5°C then the offset to be entered will be -0.5.
- 10 Enter the required offset(s) by tapping the black field containing the offset value and entering the new value.

Note:
For dual systems both left and right heaters should be calibrated as described.

Step	Action
11	Verify that the temperature is now displayed correctly on the WAVE Bioreactor touch screen.
12	To ensure linearity for cultivation conditions where temperature will be varied, test the temperature control at the required temperatures.

Ordering information

Service Cellbag bioreactors can be ordered as shown in the table below.

Part number	Description	Intended for
28412993	CB, 10L, BC10, Custom	KIT20 half tray
28412994	CB, 20L, BC10, Custom	KIT20 full tray
28412995	CB, 22L, BC10, Custom	KIT50 half tray
28412996	CB, 50L, BC10, Custom	KIT50 full tray

9.7 Maintenance of WAVEPOD II

Cleaning

Cleaning of WAVEPOD II is performed in the same manner as cleaning of WAVE Bioreactor 20/50, see *Section 9.3 Cleaning the instrument, on page 227*.

Adjustments

Please contact GE Healthcare for maintenance service every six months.

Replacement of fuses

Two fuses are located inside the power entry module:

- Fuse type: T 2AL 250V (5x20)



WARNING

Always replace fuses using the same fuse type and rating.

Follow the instruction below to replace the fuses:

Step	Action
1	Disconnect power and detach the power entry cable.
2	Locate the power entry module and pry off the fuse cover.
3	Remove and replace the fuses.
4	Replace the fuse cover.
5	Reattach the power cord and turn on the power.

10 Troubleshooting

About this chapter

This chapter is about troubleshooting of WAVE Bioreactor 20/50.

In this chapter

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10.3 WAVEPOD II	245

10.1 General problems

Cellbag inflation



NOTICE

The Cellbag bioreactor should be inflated so that it requires force to squeeze it. However, it should not be so pressurized that creases form near the attachment points.



NOTICE

An underinflated Cellbag bioreactor will generate excessive foam and poor mixing. It will cause rapid failure of the Cellbag bioreactor and possible leakage.

Error symptom	Possible cause	Corrective action
The Cellbag bioreactor appears to be overinflated.	Too high airflow	Check that the airflow to the bioreactor does not exceed 0.5 lpm.
	Faulty relief valve	Check that air is passing out of the pressure control valve: - attach a short length of tubing to the outlet vent - Immerse the tubing into water to a 1 cm depth. <i>Result:</i> Bubbles should appear indicating flow. - If no bubbles are observed, remove the pressure control valve. The pressure control valve may be plugged and removing it may allow continued operation.
	The outlet filter is closed off or blocked	- Make sure that the outlet filter is not closed off or blocked. - If foam is clogging the outlet filter, reduce the rocking speed or the rock angle.
	Faulty Cellbag bioreactor	If the Cellbag bioreactor continues to overinflate, transfer the contents to another Cellbag bioreactor.

Error symptom	Possible cause	Corrective action
The Cellbag bioreactor appears to be underinflated.	Too low airflow	Check that there is sufficient airflow to the inlet filter.
	Inlet air supply wrongly connected	Check that you have connected the inlet air supply line to the inlet filter (does not have the pressure control valve).
	Missing pressure control valve	Check that the pressure control valve is present on the outlet filter.
	Clogged inlet filter	- Check that the air inlet flow path is unobstructed. Tip: A small amount of condensate in the inlet filter is normal. However, if excessive condensate is formed: - Decrease the airflow - Check filter heater performance - Insulate the tubing to the pressure control valve

Foaming

Note: *Some amount of foam is typical and in many cases foam will subside after a few hours of operation. Foam should not cover more than 50% of the surface area.*

10 Troubleshooting

10.1 General problems

Error symptom	Possible cause	Corrective action
Excessive foaming in the Cellbag bioreactor.	Poorly inflated Cellbag bioreactor.	Check that the Cellbag bioreactor is rigidly inflated. A poorly inflated bag will foam rapidly.
	Too high rocking rate	If foam is still excessive after a few hours of operation, reduce the rocking rate. Make sure that the new rocking rate provides a sufficient dissolved oxygen concentration.
	Too high rock angle	Reduce the rock angle. The bioreactor base units are factory set to $\pm 6^\circ$ from the horizontal. This angle has been found optimal for most cell lines.
	High protein content in medium	Add antifoam

Temperature control

Note: The heater is intended to control temperature using gentle heating. It takes over 1 hour to heat 10 liters from room temperature to 37°C.

Note: The PV (Process Value) should stay within $\pm 0.2^\circ\text{C}$ of the SV (Set Point).

Error symptom	Possible cause	Corrective action
The error message FAIL is displayed.	The temperature sensor is not connected or faulty	Check that the temperature sensor is properly connected. If the problem persists, replace the temperature sensor.
	The temperature is outside the range ambient temperature + 5°C to 40°C	Adjust the temperature.
No heating and no error message.	The WAVE Bioreactor instrument is not rocking	Check that the instrument is rocking. The heater is automatically turned off when the instrument is not rocking. This can be overridden from the SETUP:HEATER menu.

Error symptom	Possible cause	Corrective action
Slow heating	The heater cable is not connected	Make sure that sensor cable is plugged into the panel and correctly positioned in the bag.
	The heater is not turned on	• Turn the heater on. • Check that the HTR ON indicator is flashing. • Check that the heater power bars are increasing or at maximum. • When using 20 L or larger Cellbag bioreactors, make sure that both heaters are running (LEFT+RGHT setting) on HEATER control screen.
	Wrong setpoint set	Check that the setpoint is set correctly.
The temperature control is not functioning or the displayed temperature appears to be incorrect.	The temperature sensor or heater are not properly installed.	• Make sure that the temperature sensor is properly positioned under the Cellbag bioreactor. • Check that the heater is correctly positioned and that the Rocker tray is latched securely.
	The Cellbag bioreactor does not cover the temperature sensor.	Check that there is enough media in the Cellbag bioreactor to cover the temperature sensor and that no crease with resulting airpocket has formed on the Cellbag bioreactor film covering the sensor.
	The temperature sensor is not properly calibrated.	Calibrate the temperature sensor.

Error symptom	Possible cause	Corrective action
The HTR FAIL alarm is activated	The temperature exceeds 60°C	 WARNING Do not touch the Rocker tray. Check that the sensor is correctly installed and that a Cellbag bioreactor is present. In the event of an overheat condition, the system will reset automatically once the heater cools down sufficiently.
	The heater is disconnected from the instrument.	Connect the heater to WAVE Bioreactor.

Rocking

Error symptom	Possible cause	Corrective action
The WAVE Bioreactor instrument does not initialize properly	Faulty safety switches	Try to restart the system a few times. If the system still does not initialize properly, shut it down and contact Technical support.
The instrument does not rock	Alarm messages	- Check the current alarms on the Alarm window on the Touch screen. - Reset power to the unit by cycling the power to the instrument. - If you still get motor alarms contact GE Healthcare Technical support for service.
The instrument stops rocking and the SAFETY SWITCH TRIPPED alarm is activated.	The rocking unit is mechanically restricted from moving	Localize and remove the restricting object.
The rocking speed changes	The optional DO controller is enabled. If the DO deviates from the setpoint the rocking speed changes.	In the case of DO control this is normal behavior. If DO control is not required, switch the DO controller OFF .

Error symptom	Possible cause	Corrective action
Incorrect angle	The rocking unit is mechanically restricted from moving	Localize and remove the restricting object. Cycle power to the instrument to reinitialize the angle measurement.

Aeration controller

Airflow should stay constant within ± 0.02 lpm.

Error symptom	Possible cause	Corrective action
No airflow, and a high pressure alarm is activated	The airpump has shut down due to high pressure	Disconnect the Air In and Air Out tubing and locate the blockage.
The airpump is running but the airflow shows zero	Blocked air tubing	Disconnect the inlet and outlet connections on the side panels. If the airflow is restored then check if the Air In or Air Out tubing is blocked.
	WAVEPOD II is connected and the gas source is incorrectly selected.	Select the correct source for gas. (WAVE Bioreactor 20/50 or WAVEPOD II)
	An external gas source is connected but the tube regulator is not opened.	Open the external gas tube regulator.
The airflow fluctuates, and a high pressure alarm is activated.	Restriction in the air tubing	Disconnect the inlet and outlet connections on the side panels. If the airflow is restored then check for restrictions in the Air In or Air Out tubing.
	Clogged Cellbag bioreactor outlet vent filter	Transfer the contents to another Cellbag bioreactor.
No airflow (PV=0)	The bag is overpressurized or the inlet to the Cellbag bioreactor is closed.	Make sure all inlet and outlet lines are open. This should result in the resumption of airflow.
	The outlet flow is restricted or clogged. This is indicated by a high pressure alarm.	Use FLTHTR2 to heat the Cellbag bioreactor outlet filter. This prevents condensation and clogging. If the outlet flow is blocked by foam, reduce the angle or lower the rocking speed.

Alarm messages

The table below lists the alarm messages that can appear on the WAVE Bioreactor 20/50 Touch screen.

Alarm	Message	Description
E1	INIT FAIL	Machine failed to initialize on power up
E2	SPEED DEV	Actual rocking speed does not match setpoint
E3	AIR DEV	Actual airflow (left) does not match setpoint
E4	TEMP DEV	Actual temperature (left) does not match setpoint
E5	WEIGHT DEV	Actual weight does not match setpoint
E6	TEMPFAIL	Temperature sensor (left) failed or unplugged
E7	HTR FAIL	Heater unplugged or over temperature
E8	ROCKFAIL	Rocker not rocking
E9	COMMFAIL	Internal communications failure. Cycle power to retry.
E10	MTRFAIL	Rocking motor failure
E11	HIPRALM_L	High bag (left) pressure.
E12	EMERSTOP	Safety bumper activated and stopped rocker
E13	CO2FAIL	CO ₂ sensor fail (2050EHT-CO2 only)
E14	PANFAIL	Not used for bioreactor
E15	RTEMPFAIL	Right side temperature sensor failed or unplugged (2050EHTD)
E16	RTEMPDEV	Actual temperature (right) does not match setpoint (2050EHTD)
E17	RAIRDEV	Actual air flow (right) does not match setpoint
E18	CO2DEV	CO ₂ deviation (2050EHT-CO2 only)
E19	HIPRALM_R	High bag pressure, right side(2050EHTD only)
E20	LOADFAIL	Weight sensor failed (only when a loadcell is installed)
E21	LOWWTALM	Low weight alarm (only when a loadcell is installed)
E22	HIWTALM	High weight alarm (only when a loadcell is installed)
E23	HARVALM	Harvest alarm (only when a loadcell is installed)

Alarm	Message	Description
E24	FEEDALM	Feed alarm (only when a loadcell is installed)
E25	LOC02PR	Low CO ₂ supply pressure (2050EHT-CO2 only)
E27	O2FAIL	O ₂ sensor fail (2050EHT-O2 only)
E28	LOO2PR	Low O ₂ supply pressure (2050EHT-O2 only)
E29	O2DEV	O ₂ deviation (2050EHT-O2 only)
E30	LOAD_OVRG	Weight exceeds sensor range

10.2 Module specific problems

Weight controller

Error symptom	Possible cause	Corrective action
No weight reading	Loadcell not installed	Check that the Loadcell option is installed and that the sensor cable to the rear of the WAVE Bioreactor instrument is connected correctly.
	Weight option is not enabled	Verify that the WEIGHT option is enabled (SET-UP:OPTIONS screen). Go the TARE screen and check that the gross weight is positive.
Erratic weight display	Mechanical obstructions to the rocking unit	Verify that the Rocker tray is firmly locked in position. Make sure that no tubing is pulling on the Cellbag bioreactor during rocking. Check that the movement of the WAVE Bioreactor instrument is not obstructed.

CO₂ controller

Error symptom	Possible cause	Corrective action
No CO ₂ reading	No CO ₂ module installed	Verify that the bioreactor base unit is type 20/50EHT-CO2.
Erratic CO ₂ control	CO ₂ gas not properly connected	Check that the CO ₂ gas to the unit is connected and at the correct pressure.

O₂ controller

Error symptom	Possible cause	Corrective action
No O ₂ reading	No O ₂ module installed	Verify that the bioreactor base unit is type 20/50EHT-O2.
Erratic O ₂ control	O ₂ gas not properly connected	Check that the O ₂ gas to the unit is connected and at the correct pressure.

10.3 WAVEPOD II

General problems

The table below gives a brief guide of how to solve general problems that might occur when using WAVEPOD II.

Error symptom	Possible cause	Corrective action
Display stays blank	The unit is not powered up.	Check the power cord.
The message: BASE NOT FOUND is displayed repeatedly	This message is displayed momentarily on startup and if communications to the connected base are lost. If the message stays on then internal communications to WAVEPOD II control modules have been lost.	Check that the cable between WAVE Bioreactor 20/50 and WAVEPOD II is correctly installed. If the problem persists, contact GE Healthcare Technical support

CO₂ MIX

The table below gives a brief guide of how to solve problems that might occur when using the CO₂ controller.

Error symptom	Possible cause	Corrective action
The display shows a CO ₂ concentration in air which deviates from the expected value (0.0%).	A minor deviation from the expected value is not unusual.	If the deviation is large, the CO ₂ offset can be adjusted. Contact GE Healthcare service.
CO ₂ reading keeps drifting down	The CO ₂ gas supply pressure is too low	Check that the green CO ₂ inlet pressure light is lit. The CO ₂ supply pressure must be between 0.7 and 1.0 bar (10 and 15 psig).
Faulty CO ₂ control	The CO ₂ supply is not properly connected	Verify that CO ₂ is connected to the correct inlet port. Check that the air pump is on and that the flow rate is between 0.05 and 0.5 liters/minute. Check that the CO ₂ switch is on.
	Wrong setpoint set	Check the setpoint on the controller.

10 Troubleshooting

10.3 WAVEPOD II

Error symptom	Possible cause	Corrective action
No airflow reading	Obstructed airflow	Check that airflow to the Cellbag bioreactor is not obstructed.
	No airflow	Make sure that the pump is working by disconnecting the MIX OUT coupling on the instrument.
The Cellbag bioreactor does not stay inflated	No airflow	Verify that there is airflow to the Cellbag bioreactor.
	Faulty check valve	Check that the check valve on the Cellbag bioreactor is correctly installed. Close off the Cellbag bioreactor outlet using the pinch clamp and see if the Cellbag bioreactor inflates. Then confirm that the check valve is working by connecting a short length of tubing to the check valve outlet and dip it into water. Tubing should be immersed to a depth of 5 to 10 mm. Opening the outlet pinch valve should cause bubbles to appear and bubbles should continue to flow as the airflow and pressure stabilizes.

O₂ MIX

The table below gives a brief guide of how to solve problems that might occur when using the O₂ controller.

Error symptom	Possible cause	Corrective action
The display shows an O ₂ concentration in air which deviates from the expected value (21.0%).	A minor deviation from the expected value is not unusual.	If the deviation is large, the O ₂ offset can be adjusted, Contact GE Healthcare service.
O ₂ reading keeps drifting down	The O ₂ gas supply pressure is too low	Check that the green O ₂ inlet pressure light is lit. The O ₂ supply pressure must be between 0.7 and 1.0 bar (10 and 15 psig).

Error symptom	Possible cause	Corrective action
Faulty O ₂ control	The O ₂ supply is not properly connected	Verify that O ₂ is connected to the correct inlet port. Check that the O ₂ supply pressure is set to 0.7 bar (10 psig) minimum. Check that the air pump is on and that the flow rate is between 0.1 and 0.5 liters/minute. Check that the O ₂ switch is on.
	Wrong setpoint set	Check the setpoint on the controller.
No airflow reading	Obstructed airflow	Check that airflow to the Cellbag bioreactor is not obstructed.
	No airflow	Make sure that pump is working by disconnecting the MIX OUT coupling on the instrument.

pH controller

Error symptom	Possible cause	Corrective action
The initial pH reading is unstable and deviates considerably (i.e., more than approximately 0.5 pH units from an offline measurement).	A gas bubble may be trapped on the pHOPT sensor.	Tap the pHOPT sensor from the underside to remove the bubble.
Fluctuating pH Variation in the pH due to the rocking motion should be less than 0.05 pH units.	The rocking motion disturbs the pH readings	Check that the cables are not pinched or moving excessively. Stop the rocking and observe the pH readings. Verify that the volume in the Cellbag bioreactor is not less than the specified minimum volume.

Error symptom	Possible cause	Corrective action
Incorrect pH reading	- Entered pHOPT calibration values are not representative for the bag used. - The pHOPT sensor is degraded due to long use, light exposure or presence of substances that are harmful to the sensor, like strong bases or ethanol.	- Check the pHOPT label on the bag, enter the correct values and perform an offset calibration. Note: <i>If the initial pHOPT reading deviates much from an offline measurement (e.g., more than 0.5 pH units) this is an indication of an abnormal condition. Check different suggested solutions in this table to find the cause of the deviation. A culture should only start when conditions are normal to avoid loss of cells.</i> - The sensor is no longer useful for pH measurement. Automatic pH control can no longer be performed.
No pH measurement	- pH measurement is not activated in the pHOPT CONTROL menu - The pH fiber optical cable is not connected properly or is defective - The temperature of the media has not reached the process temperature - The pH inside the Cellbag bioreactor is outside the readable range (appr. pH 5-9)	- Press the button to the right of the measurement window in the pHOPT CONTROL menu. - Check both ends of the fiber cable, that is, that all four pins of the bag port is gripping the bag adaptor and that the connector is properly screwed into the pHOPT port at the WAVEPOD II front. If both pHOPT and DOOPT are used, check that the fiber cables are not switched. If so, correct the connections of pHOPT and DOOPT. Note that it may take one control cycle before correct values are shown. - Turn off the pH measurement until the medium is equilibrated. Then turn on the pH measurement and make an offset calibration if necessary. - If possible, adjust the Cellbag conditions to a pH within the working range. Note: <i>It is a risk that the pH sensor has been damaged, especially if the pH was above approximately pH 10.</i>

When UNICORN DAQ is used it is possible to record some additional parameter that are of importance for troubleshooting of pHOPT. Make sure to select **pH Details** in the pH WAVEPOD configuration (**UNICORN Manager: System Setup: Components**).

DO controller

Error symptom	Possible cause	Corrective action
N ₂ is connected to the AIR IN inlet, but the DO regulation does not reduce the DO level when the set point is below 100% air sat.	The O ₂ min limit in the DO control setup screen is set to its default value of 21.0%, or any other value that is too high to create the desired DO level.	Adjust the O ₂ min limit in the DO control setup screen, for instance to 0.
The initial DO reading is much higher than expected (like approximately 300% air sat when 100% air sat should be expected).	This may occur when using both pHOPT and DOOPT sensors if the fiber cables are switched.	Correct the connections of pHOPT and DOOPT. Note that it may take one control cycle before correct values are shown.
The initial DO reading deviates from what is expected, typically around 10% air sat.	This is normal and may be caused by differences in temperature, atmospheric pressure and composition of the medium.	1 Check that the correct calibration has been entered. 2 If the problem persists, perform an offset calibration at 100% air sat and optionally 0% air sat.

Alarm messages

The table below lists the alarm messages that can appear on the WAVEPOD II Touch screen.

Alarm #	Message	Description
1	BAY1&3 FAIL	Communications with bay 1 and 3 lost
2	BAY2&4 FAIL	Communications with bay 2 and 4 lost
3	BASE COM FAIL, Communication with WAVE Bioreactor failed	Communications with WAVE Bioreactor lost

10 Troubleshooting

10.3 WAVEPOD II

Alarm #	Message	Description
10	PH_DEV	pH deviates from setpoint
11	PH_FAIL	pH sensor failed or disconnected
12	PHCOM_FAIL	pH amplifier not responding
20	DO_DEV	DO deviates from setpoint
21	DO_FAIL	DO sensor failed or disconnected
30	INIT_FAIL	PLC initialization failure
31	AIR_DEV	Airflow deviates from setpoint
32	OUTHIPRALM	MIX OUT pressure too high
40	O2_DEV	O ₂ deviates from setpoint
41	CO2_DEV	CO ₂ deviates from setpoint
42	O2_FAIL	O ₂ sensor failed
43	CO2_FAIL	CO ₂ sensor failed
44	LOWO2PR	Oxygen supply pressure low
45	LOWCO2PR	CO ₂ supply pressure low
46	O2MINLMT	O ₂ remote setpoint at minimum limit
47	O2MAXLMT	O ₂ remote setpoint at maximum limit
48	CO2MAXLMT	CO ₂ remote setpoint at maximum limit
49	CO2MINLMT	CO ₂ remote setpoint at minimum limit
50	RPMMINLMT	Speed remote setpoint at minimum limit
51	RPMMAXLMT	Speed remote setpoint at maximum limit
52	BAY 2 DOOPT NO TYPE	The DOOPT board type (DOOPT or DOOPT II) could not be detected
53	SWITCHED FIBRES	Indication that optical fibers may have been switched

Appendix A Reference information

About this appendix

This appendix contains technical data, regulatory and other information.

In this appendix

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A.1 Specifications

WAVE Bioreactor 20/50

Parameter	Value
Ingression protection	IP 20
Supply voltage	100-120 V ~ or 220-240 V ~ 50 to 60 Hz
Power	630 VA
Dimensions (h × w × d)	179 × 573 × 46 mm - With KIT20EHT: 254 × 711 × 575 - With KIT50EHT: 254 × 775 × 700
Weight	16 kg
Acoustic noise level	< 70 dB A
Ambient temperature	4°C to 40°C
Storage temperature	-25°C to +60°C
Relative humidity tolerance	< 95%, non-condensing
Inlet specifications	- Air, process gas: 0.1 - 0.2 bar (min flow rate 1.0 L/min for full airflow specification) - CO₂: 0.7-1.0 bar (min flow rate 0.2 L/min for full CO₂ specification) - O₂: 0.7-1.0 bar (min flow rate 0.6 L/min for full O₂ specification)

WAVEPOD II

Parameter	Value
Ingression protection	IP32
Supply voltage	100-120 V ~ or 220-240 V ~, 50 to 60 Hz
Power	200 VA
Fuses (2)	T 2AL 250 V (5x20)
Dimensions (h x w x d)	393 x 278 x 404 mm
Weight	12.6 kg
Acoustic noise level	< 60 dB A
Ambient temperature	4°C to 40°C
Storage temperature	-20°C to +60°C
Relative humidity tolerance	10% to 90%, non-condensing
Inlet specifications	- Air, process gas: 0.1 - 0.2 bar (min flow rate 1.0 L/min for full airflow specification) - CO₂: 0.7-1.0 bar (min flow rate 0.2 L/min for full CO₂ specification) - O₂: 0.7-1.0 bar (min flow rate 0.6 L/min for full O₂ specification)

A.2 Spare parts, accessories and ordering information

WAVE Bioreactor

For correct up to date information on spare parts and accessories for the WAVE Bioreactor instrument, visit www.gelifesciences.com/wave or contact your local GE Healthcare representative.

WAVEPOD II modules

The available WAVEPOD II modules are listed below. For correct up to date information on spare parts and accessories for the WAVEPOD II controller, visit www.gelifesciences.com/wave or contact your local GE Healthcare representative.

- pHOPT module
 - Dissolved Oxygen Control Module
 - Airpump Module
 - O₂ Gas Concentration Control Module
 - CO₂ Gas Concentration Control Module
 - Combination O₂ + CO₂ Control Module
-

Appendix B Parameter control theory

About this appendix

This appendix contains information about the WAVEPOD II parameter measurements and controls.

In this appendix

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B.1 Overview

Control functions

The control modules in WAVEPOD II contain the following functions:

Parameter	Control
pH	measurement: optical sensor regulation: acid/base addition via external pumps and/or signal to CO ₂ controller
DO	measurement: optical sensor regulation: rocking speed and/or signal to O ₂ controller
Airflow	measurement: thermal mass flow sensor regulation: internal controller
CO ₂ controller	measurement: NDIR sensor regulation: internal controller
O ₂ controller	measurement: zirconium oxide sensor regulation: internal controller

B.2 pH measurement and control

Measurement of pH, pHOPT module

The pHOPT module allows real-time measurement of the pH inside Cellbag bioreactors, using a disposable sensor integrated into the Cellbag bottom.

An optical fiber connects the Cellbag bioreactor to the pHOPT module. The optical fiber is provided with a specially designed bag adaptor for secure coupling to a pH bag port at the bottom of the Cellbag bioreactor.

The pH bag port holds the pH sensor, which is a 2 mm luminophore spot, sensitive to variations in pH.

The optical measurement principle reduces sensitivity to electromagnetic interference.

Measurement principle for pHOPT

Optical sensor technology

The optical sensor technology is based on the use of a dye comprising two luminophore substances immobilized on the sensor body. On excitation by incident light, the luminophores emit light. One of the luminophores has a decay time that is constant within the sensor's useful pH range of operation, while the decay time of the other luminophore is dependent on the pH of the surrounding solution.

Measuring pH

To measure the pH of a solution, the well soaked pH sensor is illuminated by a LED with a modulated light pulse. The light pulse will excite the sensor, resulting in similarly modulated responses emitted from the two luminophores.

Due to the different decay times of the luminophores the response signals will be delayed with respect to each other. This is manifested as a phase angle difference. Since the decay time of one of the luminophores varies according to the actual pH environment, the phase angle between the response signals can be used to calculate pH.

A transfer function is used to convert the phase angle to a pH reading. The transfer function includes a set of parameters (calibration values) that are specific for a sensor batch: c_{min} , c_{max} , c_{pH0} and c_{dPH} . A fifth calibration value is c_{temp} , the temperature at which the sensor was calibrated and at which it should be used for optimal performance. All calibration values are provided on a label on the Cellbag bioreactor.

Compensation for light and temperature sensitivity

The sensor is subject to photobleaching, that is, its properties are affected by light. This includes the light from the LED used for measurement. Photobleaching results in loss of intensity (amplitude) and increasing phase angle (decreasing pH reading).

The LED output is automatically regulated to provide suitable amplitude for optimal performance and life time of the sensor.

The sensor is also temperature sensitive. The pHOPT module includes temperature compensation, which is effective within a few °C around the calibration temperature.

Offset calibration

An offset calibration according to *Section 6.3.1 pH control, on page 121* will change the cpH0 calibration value. The other calibration values remain constant during the cultivation.

Control of pH

pH is controlled using one of the following alternatives:

- addition of acid and base
- addition of CO₂ gas and base addition

There is one control algorithm with PID settings for acid/base control and another algorithm for CO₂ control with other PID settings. The reason for this is the different dynamics in the liquid and gas phases, respectively. When the combined CO₂/base regulation is used, the base settings are those entered for the acid/base control (with acid regulation inactivated).

A table of recommended PID values is provided in *Set pH control parameters, on page 191*.

The basis for pH regulation is the control cycle, that is, the time interval between pH regulating actions. At the beginning of the control cycle, the regulator determines how long time (measured as a percentage of the control cycle time) an acid/base pump must be active to counteract a deviating pH. In the case of CO₂, the CO₂ level necessary to regulate pH during the next control cycle, is determined by the controller.

The control cycle time can be set by the user. It may be the same as the sample interval, that is, the time between two consecutive readings of the pH.

Use of dead band

Generally, the use of dead band is a way to limit the regulator from being active in order to prevent it from wasting media or energy without resulting in a noticeably better regulation.

The pHOPT module has functions to set deadbands for both acid/base and CO₂/base control.

Acid/base deadband

Sometimes a pH range is used to define a control dead band. However, if the volume and chemical characteristics of the controlled system are not well defined, or is fluctuating with time, the correlation between pH and the regulation is not stable. This is the case in a typical cell culture during acid/base control.

The amount of added acid or base is controlled by turning on the pumps for a certain percentage of the time in each control cycle. With pHOPT, a good pH regulation is instead achieved by defining a time threshold under which the acid/base pumps are not active.

Normally, even under stable conditions, the pH varies a few hundredths of a pH unit around the pH set point. If the acid/base pumps were active to counteract such small deviations, they would pump acid/base more or less constantly without a noticeably improved regulation. This would result in unnecessary consumption of acid/base and an excessive filling of the Cellbag bioreactor.

pHOPT acid/base deadband setting

In the pHOPT Setup, the acid/base deadband is implemented as a percentage of the user defined control cycle. For instance, assume that the control cycle is set to 50 seconds and the dead band is set to 2.0%. Depending on the size of the measured deviation from the selected pH set point, the regulator calculates the time the pump must be active to counteract the deviation. If the deviation is so small that the calculated time is less than 2% of 50 seconds (1 second) then the regulator will not activate the pump during that control cycle. Consequently, the pump will not be activated until the pH deviation at the beginning of a control cycle calls for a pump action longer than 1 second.

The default setting is 2.0%. A lower setting of the deadband may give a slightly less fluctuating regulation but at the cost of increased acid/base consumption.

CO₂ deadband

The CO₂ regulation also includes a deadband that can be set by the user. The CO₂ deadband defines the pH interval around the selected pH set point for which the regulation is inactive, meaning that the CO₂ level is constant.

pHOPT CO₂ deadband setting

In the pHOPT module, setting the CO₂ dead band to pH 0.0 will give optimal regulation. This is the default value, and should always be used unless a special application makes it necessary to change the dead band setting.

Transition delay time

In the case of CO₂/base regulation, CO₂ will be added as long as pH is above the pH control set point, while base will be added to increase a too low pH. For stable regulation, these two modes of regulation should not toggle too frequently. This would be the case when the measured pH is very near the set point.

Therefore, a transition delay time can be set for the change from CO₂ to base regulation, and a similar second delay time for the change from base to CO₂ regulation.

Toggleing from CO₂ to base regulation takes place only when pH is below the set point for the defined delay time, and at the same time the CO₂ controller is at its selected minimum CO₂ level. Correspondingly, the base regulation is changed to CO₂ regulation only when the pH is above the set point and no base has been added for the set delay time.

Gain

The gain parameter for the acid and base pumps allow the user to adjust the acid/base output to account for differences in strength between the acid and base used.

The gain factor is a unitless number. Increasing the acid and base gain increases the effect of the regulator output.

B.3 DO measurement and control

Measurement of DO, DOOPT II module

The DOOPT II module allows real-time measurement of the dissolved oxygen inside Cellbag bioreactors, using a disposable DO sensor integrated into the Cellbag bottom film.

An optical fiber connects the Cellbag bioreactor to the DOOPT II module. The optical fiber is provided with a specially designed bag adaptor for secure connection to a DOOPT II bag port in the bottom of a DOOPT II configured Cellbag bioreactor.

The DOOPT II bag port holds the DOOPT II sensor, which is a 3 mm luminophore disc, sensitive to variations in dissolved oxygen.

The optical measurement principle reduces sensitivity to electromagnetic interference.

DOOPT measurement principle

The optical sensor technology for DOOPT II is based on the use of a sensor disc layer comprising a luminophore substance immobilized on a disc. The disc is glued onto the sensor body.

The DOOPT II module measures the luminescence decay time of the immobilized luminophore.

The luminophore is typically a transition metal complex. On excitation by incident light, the luminophore emits light. In the presence of a quencher, such as molecular oxygen, the luminophore becomes deactivated and does not emit light with the result that the decay time is dependent on the concentration of oxygen in its surrounding.

The luminescence decay time is measured using a phase-modulation technique. The luminophore is excited with sinusoidally modulated light. The decay time of the luminophore causes a delay in the emitted light signal. This delay is manifested as a shift in the phase angle between the excited and the emitted light signal.

The DOOPT II module allows for temperature compensation.

Control principle overview

DO is controlled using one of the following alternatives:

- change of rocking speed
- change of O₂ concentration
- combination of rocking speed and O₂ concentration

There is a control algorithm for O₂ control with PID settings available to the user, while the parameters for the rocking speed are preset. Controlling actions will not be performed within the deadband. When the combination mode is selected, the O₂ control is primarily used. If it is insufficient for reaching the set point, the rocking speed control is applied. To minimize the occurrence of undesired toggling when the measured value is close to the set point, a transition delay value is set.

Deadband

The deadband for rocking speed and O₂ is expressed as the difference between the DO set point and the measured DO value. The deadband defines the interval around the DO set point for which the regulation is inactive.

If measured DO is...	Then...
higher than set point	speed and/or O ₂ concentration are decreased to reach the DO set point, down to a set minimum value. When a combination is used, O ₂ is controlled first until its minimum value, then speed is decreased.
lower than set point	speed and/or O ₂ concentration are increased to reach the DO set point, up to a set maximum value. When a combination is used, O ₂ is controlled first until its maximum value, then speed is increased.

Rocking speed

When the measured DO is within the deadband no changes are made to the rocking speed.

O₂

Setting the O₂ deadband to 0.0 will give optimal regulation. This is the default value, and should be used unless a special application makes it necessary to change the deadband setting.

Transition delay

Transition delay applies to the combination control scheme. When the measured DO value is below set point, despite of maximum O₂, the rocking speed control is also used. Transition delay is set to avoid that the speed control is turned on and off frequently when the DO value fluctuates close to set point at maximum O₂. The need for speed control must be consistent during this time for the control to be turn on. The control will be turned off when it hasn't been needed during the set time, as well.

Air saturation and atmospheric pressure

With WAVEPOD II, DO is measured as percent air saturation (% air sat).

100% air sat represents the oxygen content of a certain solution at the current temperature and atmospheric pressure when it has been equilibrated in an environment of air.

Air saturation is a relative measure. The oxygen content as measured in, for instance, mg/l depends on factors such as the composition of the solution, temperature and atmospheric pressure (due to different weather conditions or altitude).

Thus, it shall be understood that if a DOOPT II sensor is calibrated for 100% air sat under equilibrated conditions at one atmospheric pressure, such as 1030 mbar, it will not show 100% air if the same content is later equilibrated at another atmospheric pressure, say 950 mbar. The difference is approximately 1% air sat/10 mbar.

As delivered, the DOOPT II configured Cellbag bioreactors have sensors that are factory calibrated at a certain atmospheric pressure. This pressure is stated on the DOOPT II label as "calp" and can be entered into WAVEPOD II. However, since WAVEPOD II does not include a barometer no algorithm for pressure compensation is available.

B.4 Oxygen measurement and control

Function

O₂ from a pipeline or cylinder is connected to the O₂ module. Air is drawn from the **Air In/AIR IN** port (airpump module) and mixed with the O₂ (connected to **O2 IN**). An O₂ sensor measures the O₂ concentration in the air and controls it to any user-specified value from 21 to 50%. The conditioned air is pumped from the **Air Out/MIX OUT** port into the headspace of Cellbag to maintain bag pressure, and to provide oxygen to the culture.

Measurement principle

The oxygen concentration in the gas is measured using an internal zirconium oxide sensor. The oxygen specific chemistry produces a signal proportional to the oxygen present in the flow through cell and microprocessor circuitry provides a linear and stable signal. The internal controller regulates how much O₂ gas to mix with air to produce the desired O₂ concentration to the Cellbag headspace.

The O₂ sensor is temperature compensated (0 to 50°C). Pressure changes can influence the reading; however, the gas flow is carefully regulated to maintain constant pressure in the O₂ sensor cell regardless of **Air Out/MIX OUT** delivery pressure or minor fluctuations in O₂ inlet pressure.

Sensor life time

The O₂ sensor does not degrade when not in use. Under typical operating conditions, the sensor should last 10 years.

B.5 Carbon dioxide measurement and control

Function

CO₂ from a pipeline or cylinder is connected to the CO₂ module. Air is drawn from the **Air In/AIR IN** port (airpump module) and mixed with the CO₂ (connected to **CO2 IN**). A CO₂ sensor measures the CO₂ concentration and controls it to any user-specified value from 0 to 15%. The CO₂ conditioned air is pumped from the **Air Out/MIX OUT** port into the headspace of Cellbag to maintain bag pressure, and to provide carbon dioxide for pH control.

Measurement principle

CO₂ is measured by a Non-dispersive infrared (NDIR) CO₂ sensor using a flow-through cell. The internal controller and valve regulates CO₂ gas to mix with air to produce the desired CO₂ concentration in the gas to the Cellbag headspace.

The CO₂ sensor is temperature compensated (0 to 50°C). Pressure changes can influence the reading; however, the gas flow is carefully regulated to maintain constant pressure in the CO₂ sensor cell regardless of **Air Out/MIX OUT** delivery pressure or minor fluctuations in CO₂ inlet pressure.

Appendix C Communications and connections

About this appendix

This appendix describes how to connect WAVE Bioreactor 20/50 to WAVEPOD II and other stand-alone WAVE instruments, and to UNICORN DAQ 1.0 and how they communicate.

In this appendix

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C.5 MODBUS communication port	273
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C.1 Data communication overview

Data communication options

Two options for data communications are built into WAVE Bioreactor and WAVEPOD II: analog and digital.

Type	Contact/protocol	Communication with
Relay logic	Dry contact	Alarm monitoring systems
Analog	Analog outputs	- Data loggers - Control software
Digital	MODBUS (RTU)	- Data acquisition software such as UNICORN DAQ 1.0 - WAVE Bioreactor: WAVEPOD II, WAVEPOD II: WAVE Bioreactor - Daisy chain of WAVE Bioreactor and stand-alone instruments

Analog communication

Alarm

A unit alarm is available on the back panel jack of both WAVE Bioreactor (**ALARM ANALOG OUTPUT**) and WAVEPOD II (**ALARM/ANALOG**). This is a normally closed or normally open dry contact that will activate if any of the alarms are tripped. Using the normally closed contact also provides an alarm if power is lost to the instrument. The alarm contact can be used to interface to user-supplied alarm monitoring systems.

Additional options in WAVE Bioreactor instruments

In addition to the above, the following parameters can be measured from the back panel of WAVE Bioreactor instruments as separate voltages:

- speed
- temperature
- airflow

- weight
-

Digital communication

Digital communication ports are provided on the back panel of WAVE Bioreactor (**DATA-PORT 1 and 2**) and WAVEPOD (**CONVERTER, WAVE 20/50**) for RS485 multidrop data acquisition via the industry standard MODBUS protocol. These ports are used for connecting other WAVE instrumentation over a single RS485 cable and for data acquisition and supervisory control.

Note: *Each WAVEPOD II can control only one WAVE Bioreactor instrument and one Cellbag bioreactor. However, two WAVEPOD II controllers can be used for a dual mode WAVE Bioreactor instrument, where one WAVEPOD II controls the WAVE Bioreactor instrument and one Cellbag, and the other WAVEPOD II controls only the other Cellbag. Both WAVEPOD II can be connected to a Converter100 and a computer for data acquisition.*

Multiple WAVEPOD II controllers can be networked using standard Ethernet routers between converters and a computer for data acquisition, see Section C.6 Connecting WAVE Bioreactor with UNICORN DAQ 1.0 , on page 275.



NOTICE

The **AUX** connector is only to be used by GE Healthcare service personnel.

C.2 Analog/alarm port



NOTICE

Use shielded cables only.

Note: The maximum cable length is 3 m.

Connector jack on WAVE Bioreactor and WAVEPOD II

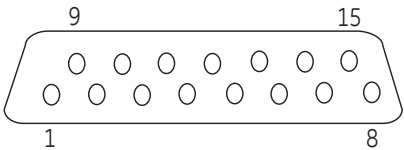
WAVE Bioreactor and WAVEPOD II have a DB15 female jack on the back panel, providing analog signals and alarm contacts. A standard DB15 male connector is used to connect to this port.

The analog channels can be set to either

- 0 to 5 V
- 1 to 5 V

on the **SETUP > ANALOG** screen. The default pinouts are shown in the following tables, together with ranges.

DB15 port: pinout and ranges



Pinout in WAVE Bioreactor

Alarm contact specifications: 30 Vrms / 70 mArms

PIN	Default parameter	Signal	Range
1	Speed	Analog ch 1	0 to 50 rpm
2	Weight (optional)	Analog ch 2	0 to 40 kg
3	Airflow (left)	Analog ch 3	0 to 1.0 lpm
4	Temperature (left)	Analog ch 4	0 to 50°C

C Communications and connections

C.2 Analog/alarm port

PIN	Default parameter	Signal	Range
5	Airflow (right) or CO ₂ % or O ₂ %	Analog ch 5	0 to 1 lpm or 0 to 15% CO ₂ or 0 to 50% O ₂
6	Temperature (right)	Analog ch 6	0 to 50°C
7	Analog, common		
8	Analog, common		
9	Factory use only		
10	Factory use only		
11	Factory use only		
12	Unit Alarm + contact Closes on alarm	Dry contact	
13	Unit Alarm + contact Closes on alarm	Dry contact	
14	Unit Alarm + contact Opens on alarm	Dry contact	
15	Unit Alarm + contact Opens on alarm	Dry contact	

Pinout in WAVEPOD II

Alarm contact specifications: 30 Vrms / 70 mArms

PIN	Default parameter	Contact
1 to 10	Reserved for future use	
11	Reserved for factory use	
12	Unit Alarm + contact Closes on alarm	Dry contact
13	Unit Alarm + contact Closes on alarm	Dry contact
14	Unit Alarm + contact Opens on alarm	Dry contact
15	Unit Alarm + contact Opens on alarm	Dry contact

C.3 Alarm contact

Overview

A unit alarm is provided on WAVEPOD II and WAVE Bioreactor in the form of a dry contact. The unit alarm is tripped on various alarm conditions, as configured using the touch screen.

Wiring options

The dry contact can be wired in the following ways:

- **Open on alarm:** The contact opens if an alarm or power loss occurs.
 - **Close on alarm:** The contact closes if an alarm or power loss occurs.
-

Alarm contact specifications

Parameter	Value
Load voltage, max	30 Vrms
Load current, max	70 mArms

C.4 Connecting PUMP20 to WAVEPOD II

Introduction

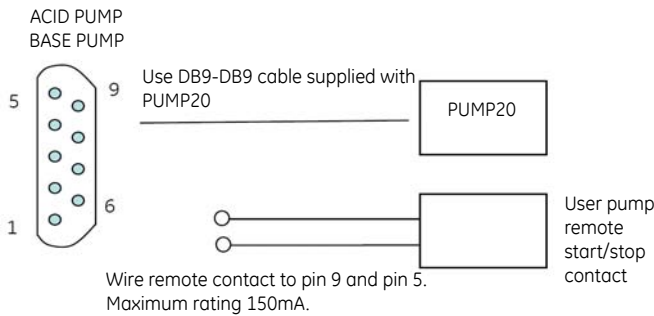
For pH control using WAVEPOD II, a peristaltic pump is needed. This section describes the WAVEPOD II communication with PUMP20.

Connector description

On the rear panel of WAVEPOD II, there are two DB9 connectors for connecting PUMP20 acid and base pumps.

Connector marking	Intended for
ACID PUMP	Acid pump
BASE PUMP	Base pump

Connectors, cables and pinouts



Parameter	Value
Connector type	DB9 female
Cable type	DB9-DB9 (supplied with PUMP20)

C.5 MODBUS communication port

Overview

There are MODBUS communication ports on both WAVEPOD II and WAVE Bioreactor. Two RJ11-6 telephone style jacks are provided on the rear panel of the WAVEPOD II controller to connect to a WAVE Bioreactor instrument (**WAVE 20/50**) and to a converter (**CONVERTER**), connected to a PC hosting UNICORN DAQ 1.0.

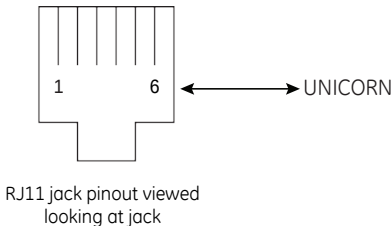
Two RJ11 jacks (**DATAPORT 1** and **2**) are provided on the rear panel of the WAVE Bioreactor instruments to connect to WAVEPOD II, to stand-alone instruments or to a Converter 100, connected to a PC hosting UNICORN DAQ 1.0.

Connection parameters

Parameter	Value
Communication protocol	MODBUS RTU
Default MODBUS address	WAVE Bioreactor:10 WAVEPOD II: 11
Parity	No parity
Data bits	8
Stop bits	1

RJ-11 jack pinout

Note: A Converter 100 is required between the RJ11 jack and the PC hosting UNICORN DAQ 1.0.
This type of jack is also used for connection to WAVEPOD II.



RJ-11 pin	Signal
Pin 1	24 VDC / 250 mA max
Pin 2	DATA B (+)
Pin 3	COM
Pin 4	SIGNAL GND
Pin 5	DATA A (-)

Modbus cable



NOTICE
Use shielded cables only.

One MODBUS cable is supplied with the instrument.

C.6 Connecting WAVE Bioreactor with UNICORN DAQ 1.0

About UNICORN DAQ 1.0

UNICORN DAQ 1.0 is an optional software provided by GE Healthcare and available for creating a WAVE Bioreactor 20/50 system consisting of WAVE Bioreactor 20/50 with Rocker tray and Cellbag, optional WAVEPOD II and UNICORN DAQ.

UNICORN DAQ is installed on a host PC and provides monitoring, data acquisition and data evaluation. For more information, read UNICORN DAQ 1.0 - User manual for WAVE Bioreactor, visit www.gelifesciences.com/wave or contact GE Healthcare.

Note: Contact GE Healthcare if other software is used to control your WAVE Bioreactor.

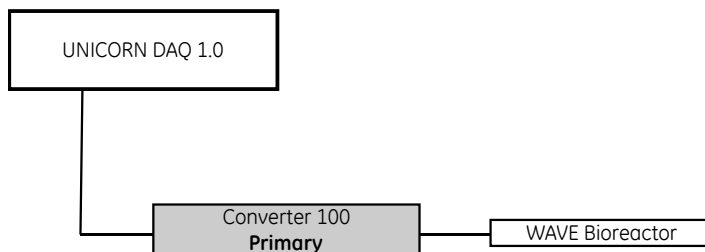
Requirements

Connecting WAVE Bioreactor instruments with UNICORN DAQ requires a Converter 100, provided by GE Healthcare, and communication cables.

Communication protocol

The communication protocol used by WAVE Bioreactor is MODBUS (RTU). The converter provides the computer and UNICORN DAQ with the communication protocol Profibus™ (Ethernet). To address any device, you must provide the IP address of the converter.

Example simple system setup

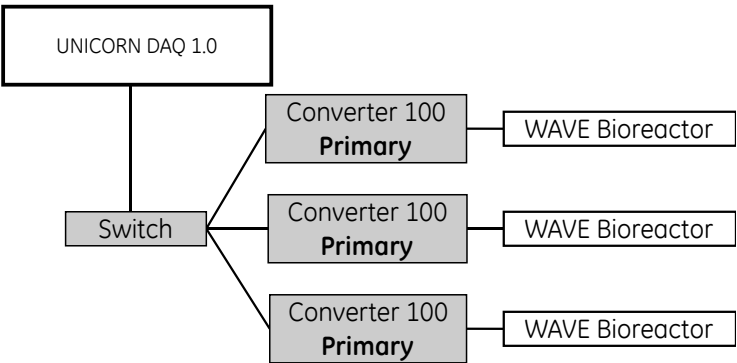


Example network

For installation of networks including several instruments, please contact GE Healthcare service.

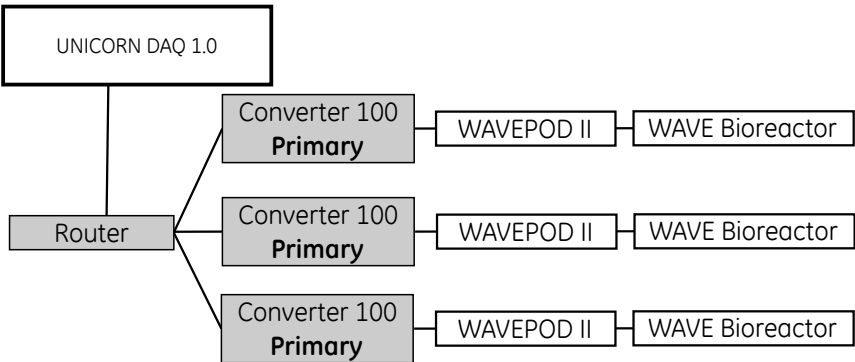
Example network with three WAVE Bioreactor instruments connected to UNICORN DAQ

The WAVE Bioreactor 20/50 instruments in the network are connected to each converter using a Modbus (RTU) link. Each converter is connected to the router. The router is connected to the computer hosting UNICORN DAQ 1.0.



Example network with three WAVEPOD II controllers

The WAVE Bioreactor 20/50 instruments in the network are connected to each WAVEPOD II using a Modbus (RTU) link. Each WAVEPOD II controller is connected to a converter. The converters are connected to the router. The router is connected to the computer hosting UNICORN DAQ 1.0.



Within the subnetwork, each instrument must have a unique address, but instruments on different subnetworks may have the same address.

For local office contact information, visit
www.gelifesciences.com/contact

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